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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Advertisement page 70, August 4.

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819

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designed and constructed by
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See their Illus. Advertisement, page 95, last week.
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Birkenhead.
See Illustrated Advertisement Page 109, Jan. 20, 1921.

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Steam and Electric Cranes
EXCAVATORS, CRANE-HAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 637
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STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement Page 62. 9052

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HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING
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FUEL OIL BURNING SYSTEMS, HEATERS, STRAINERS.
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CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 840

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Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 946

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Any class of tools. H. S. Chasers for adjustable die heads. Case hardening, colouring, etc. We can case harden Cast Iron for gauges, press tools, etc. Write us for particulars. Reliable Work! Right Prices! Delivery to promise!
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Two and Four stroke, 350, 1000, 1200 H.P., excellent condition. Dynamos for above 250 or 500 volts, D.C. Immediate delivery and low price.
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Electrical driven Centrifugal, Ram and other Pumps from 1½ in.-10 in. outlet.
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LAND AND MARINE
YARROW BOILERS.
819

Matthew Paul & Co., Ltd.
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See Full Page Advt., page 60, July 21.

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Walter Somers, Limited, HALESOWEN. 7116

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About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full page Advertisement, page 64, July 21. 8196

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LIMITED.
See Advertisement page 54. 3482

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MOTHERWELL, SCOTLAND. 9737
See half-page Advertisement page 72, August 4.

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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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TENDERS.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of :—

1. COPPER PLATES FOR LOCOMOTIVES.
2. ZINC TILES OR SLABS.
3. STEEL WIRE, ANNEALED, GALVANIZED AND BLACK.

Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m. on Friday, the 25th August, 1922, for No. 1, and on Friday, the 1st September, 1922, for Nos. 2 and 3.

T. RYAN,
Director-General. U 970

STATE ELECTRICITY COMMISSION OF VICTORIA.

FEED WATER EVAPORATORS—SPECIFICATION No. 257.

Prospective Tenderers for the

above plant are hereby notified that the date for the receipt of Tenders by the Commission in Melbourne has been extended from September 1st until October 2nd, 1922. Copies of the Specification, Tender Form, &c., may be obtained from the Agent-General for Victoria, Melbourne Place, Strand, London, W.C. 2. Charges: £3 3s. for the first two copies and 10s. 6d. per copy thereafter.

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand, London. U 966

RISBRIDGE UNION.

NEW BOILER, BOILER SETTING, BOILER HOUSE, CHIMNEY SHAFT, ETC.

The Guardians of the Risbridge Union invite

Tenders for Erection of

BOILER HOUSE, CHIMNEY SHAFT and BOILER SETTING, &c., at Kedington Institution, near Haverhill, in accordance with Plan and Specifications prepared by their Architect, Mr. H. B. THAKE, of Haverhill, at whose Office the Plan and Specifications can be seen or copies will be supplied by him on payment of the sum of £1 1s. which will be returned on receipt of a *bona fide* Tender.

The Guardians also invite Tenders for a new CORNISH BOILER, 30 ft. long by 6 ft. diameter, as per Specifications prepared by the Vulcan Boiler and General Insurance Co., Ltd., of 67, King Street, Manchester, copies of such Specifications can be obtained on application to the undersigned.

Sealed Tenders must be sent to me at my Office marked "Tender for Boiler Works or Boiler," as the case may be, so as to reach me not later than the second post Tuesday, August 29th, 1922.

The Guardians do not bind themselves to accept the lowest or any Tender.

By Order,
S. L. BIGMORE,
Clerk.

Office,
3, Wratting Road,
Haverhill,
West Suffolk. U 962

BOROUGH OF REIGATE.

The Town Council of the said Borough invites

Tenders for the Supply and

LAYING of additional HIGH PRESSURE CONCENTRIC and LOW PRESSURE TWIN PAPER INSULATED CABLES.

General Conditions, Specifications and Forms of Tender can be obtained from the Consulting Engineer, Mr. C. H. WORDINGHAM, C.B.E., M.Inst.C.E., 7, Victoria Street, London, S.W. 1, and 11, Mosley Street, Manchester, upon payment of a deposit of Three Guineas (returnable on receipt of *bona fide* Tender). Extra copies One guinea each not returnable.

Sealed Tenders, endorsed "Tender for Mains," addressed to the undersigned at the Municipal Buildings, Reigate, must be delivered not later than Ten a.m. on Tuesday, the 22nd August instant.

The Council does not bind itself to accept the lowest or any Tender.

By Order,
ALFRED SMITH,
Town Clerk.

Municipal Buildings,
Reigate.
5th August, 1922. U 975

TYNE IMPROVEMENT COMMISSION.

LOCOMOTIVE TANK ENGINE FOR THE COMMISSIONERS' NORTHUMBERLAND AND ALBERT EDWARD DOCKS.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Supply and

DELIVERY of ONE LOCOMOTIVE TANK ENGINE for their Northumberland and Albert Edward Docks.

Copies of the Form of Tender, Conditions of Contract and Specification, may be obtained on application to the undersigned on payment of a deposit of £1 which will be returned on receipt of a *bona fide* Tender.

Tenders, in sealed envelopes, endorsed on the cover "Tender for Locomotive," must be addressed to the undersigned, and delivered to him not later than noon on Wednesday, the 30th day of August, 1922.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
J. McDONALD MANSON,
General Manager and Secretary.
Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
1st August, 1922. U 966

TYNE IMPROVEMENT COMMISSION.

BOILER FOR LOCOMOTIVE TANK ENGINE FOR THE COMMISSIONERS' ALBERT EDWARD DOCK, NORTH SHIELDS.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Supply and

DELIVERY of ONE BOILER for their Locomotive Tank Engine No. 11, at the Albert Edward Dock, North Shields.

Copies of the Form of Tender, Conditions of Contract, Specification, and Drawing, may be obtained on application to the undersigned on payment of a deposit of £1 which will be returned on receipt of a *bona fide* Tender.

Tenders, in sealed envelopes, endorsed on the cover "Tender for Locomotive Boiler," must be addressed to the undersigned, and delivered to him not later than noon on Wednesday, the 30th day of August, 1922.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
J. McDONALD MANSON,
General Manager and Secretary.
Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
1st August, 1922. U 967

TYNE IMPROVEMENT COMMISSION.

FOUR DIAMOND CROSSINGS FOR THE COMMISSIONERS' ALBERT EDWARD DOCK, NORTH SHIELDS.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Supply and

DELIVERY of FOUR DIAMOND CROSSINGS for their Railways at the Albert Edward Dock, North Shields.

Copies of the Form of Tender, Drawing and Specification may be obtained on application to the undersigned on payment of a deposit of £1 which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes endorsed on the cover "Tender for Diamond Crossings" must be addressed to the undersigned, and delivered to him not later than noon on Wednesday, the 30th day of August, 1922.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
J. McDONALD MANSON,
General Manager and Secretary.
Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
1st August, 1922. U 968

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Following :—

23 CARRIAGE AND DINING CAR UNDER-FRAMES, 5 ft. 6 in. gauge.

Specifications and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 10th August, 1922.

A fee of £1 1s. will be charged for the specification, which will not be returned.

Tenders must be submitted not later than noon on Thursday, 24th August, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

By order of the Board,
T. E. WYNNE,
Managing Director. U 969

LONDON COUNTY COUNCIL.

Tenders are Invited for the

SUPPLY and ERECTION of WROUGHT IRON STANDARDS and WIRE NETTING, about 1060 ft. in length, at Southwark Park, S.E. Plans, Specification and Form of Tender may be had on application to the CHIEF OFFICER, Parks Department, The County Hall, Westminster Bridge, S.E., and are to be returned in the envelope provided for the purpose and delivered to the Clerk of the Council at the County Hall before 4 p.m. on 28th August. No tender received after that time will be considered. The Council does not bind itself to accept the lowest or any tender.

JAMES BIRD,
Clerk of the London County Council. U 963

TO ELECTRICIANS AND OTHERS.

The Metropolitan Asylums Board invite separate

Tenders for :—

(a) The INSTALLATION of TELEPHONES at Colindale Hospital, Hendon, N.W. 9;
(b) The SUPPLY and ERECTION of an ELECTRIC STORAGE BATTERY at the Grove Fever Hospital, Tooting Grove, S.W. 17,

in accordance with Drawings and Specifications prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Drawings, Specifications, and Forms of Tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m. on Saturday, 12th August, 1922, and the Drawings, Specifications, and Forms of Tender can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specifications and Drawings have been returned.

Tenders addressed as noted on the form must be delivered at the office of the Board not later than 2.30 p.m. on Wednesday, 30th August, 1922.

(By Order) G. A. POWELL,
Acting Clerk to the Board. U 961

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of :—

1. STEEL BOILER PLATES.
2. STEEL AXLES for Locos., Carriages and Wagons.
3. STEEL BOILER TUBES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Steel Boiler Plates" or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 1st September, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10/- for each copy of the Specifications Nos. 1, 2 and 3.

Copies of the Drawings may be obtained at the Offices of Messrs. R. WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.
91, Petty France, Westminster, S.W. 1.
11th August, 1922. U 987

CITY OF BIRMINGHAM ELECTRIC SUPPLY DEPARTMENT.

NECHELLS GENERATING STATION—WORKSHOP EQUIPMENT.

Tenders are Invited for the

SUPPLY, DELIVERY and ERECTION of POWER DRIVEN LATHES, MACHINE TOOLS, LINE SHAFTING and PULLEYS at the Nechells Generating Station.

Copies of the General Conditions, Drawings, Specification and Form of Tender can be obtained on application to the undersigned accompanied by a deposit of One guinea, which will be refunded after the tenders have been dealt with by the Electric Supply Committee, provided the Contractor shall have sent in a *bona fide* tender. The Committee does not bind itself to accept the lowest or any Tender.

Contractors must at the time of tendering, and at all times during the execution of the works, be paying their work-people not less than the trade union or standard rate of wages in the districts where such work-people are actually engaged in the execution of the works, and must be observing the recognised hours and conditions of labour.

Tenders addressed to the City Electrical Engineer and endorsed "Tender for Machine Tools," must be delivered here on or before September 20th, 1922.

H. J. JENNINGS,
Secretary.
14, Dale Buildings, Birmingham.
5th August, 1922. U 977

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby Invited

for the Supply, Delivery, etc., of the following for the Morwell Power Scheme.

Copies of Tender Forms and Specification will be available upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand, London, W.C. 2.

SPECIFICATION No. 265—TRANSFORMERS, INDUCTION REGULATORS AND SWITCH GEAR.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract, Specification and Drawings complete. These charges will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10/6 each.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £100 is to be lodged with the Tender.

The Specification may be inspected at the above mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Noon, 4th November, 1922.

R. LIDDELOW,
Secretary.
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. U 968

APPOINTMENTS OPEN.

Royal School of Mines

PERCHERVILLE RESEARCH FELLOWSHIPS.

The Imperial College of Science and Technology, South Kensington, London, S.W. 7, with which the Royal School of Mines is incorporated, is OFFERING TWO RESEARCH FELLOWSHIPS of £300 a year each, tenable for one year and possibly renewable for a second year, to aid in carrying out any investigation or research connected with Mining, Mining Geology, Metallurgy, or the Technology of Oil, which in the opinion of the Selection Committee is of sufficient use or promise.

Applicants who may be Associates of the Royal School of Mines or others, and preferably men with some practical experience, should apply in writing to the SECRETARY of the College (from whom further particulars may be obtained) before 1st September, 1922, giving the nature of the proposed investigation, qualifications for the work and references.

It is anticipated that the Committee will make the awards by the end of November, so that the Fellowships and work may begin on 1st January, 1923. Holders will be expected to devote their whole time to the work, which may be conducted at the Imperial College, or in special circumstances elsewhere at the direction of the Committee. U 849

Assistant to Chief Engineer

for Maintenance of Plant in Central Africa; sound practical and theoretical experience, and good education essential; able to handle men; knowledge of Oil Mill Machinery, and control of Stores, also some French desirable. Write, giving full particulars of qualifications, experience, salary expected, and age, which should, preferably, not exceed 30-32.—Box D 401, LEE & NIGHTINGALE, Advt. Offices, Liverpool. U 964

CALCUTTA IMPROVEMENT TRUST.

A Temporary Assistant En-

GINEER is REQUIRED to supervise the construction of a 3-hinged REINFORCED CONCRETE ARCH BRIDGE of 120 ft. span in the north of Calcutta.

Candidates must have had several years' practical experience in the construction of arch bridges or similar important works in reinforced concrete. Salary Rs.1000 (one thousand) per mensem, with a motor car allowance of Rs.100 (one hundred) per mensem and a free passage to and from Calcutta. Appointment for two years, subject to six months' notice on either side. Applications will be received up to the 31st August, 1922, in England by C. H. BOMPAS, Esq., C.S.I., I.C.S., Mayfield, Seaton, Devon, and in India by the Chief Engineer, Calcutta Improvement Trust, 3, Clive Street, Calcutta.

T. EMERSON,
Chairman.
Calcutta,
5th July, 1922. U 907

SOUTH AFRICAN RAILWAYS ELECTRIFICATION.

Applications are Invited for

the following positions :—

ENGINEER in connection with extra high voltage transmission system. Previous experience in the laying out and erection of extra high voltage transmission lines (20,000 volts or over) is essential. Salary from £700 to £850 according to qualifications plus passage from England and two years' engagement.

ENGINEER in connection with the distribution system. Experience in the erection of large motor generators and rotary plant and in the operation of high voltage distribution systems is essential. Salary £600 plus passage from England and two years' engagement.

ENGINEER for the Track Equipment, with experience in the erection of overhead equipment on electric railways operating at 1000 volts or over. Salary £600 plus passage from England and two years' engagement.

Applications should be accompanied by medical certificate of health, equivalent to Army A.1 qualification.

Applications, without testimonials, marked "Transmission," "Distribution," or "Track," and stating name, age, education, engineering training, and details of practical experience, must be received by Messrs. MERZ & MCLELLAN, 32, Victoria Street, Westminster, London, S.W. 1, England, not later than 4th October, 1922.

Applications from South African candidates may, if preferred, be submitted to Messrs. MERZ AND MCLELLAN, care of the GENERAL MANAGER, South African Railways and Harbours Administration, Capetown, not later than 1st September, 1922. U 999

CITY OF BRADFORD.

ELECTRICITY DEPARTMENT.

DEPUTY CITY ELECTRICAL ENGINEER.

Applications are Invited for

the POST of DEPUTY CITY ELECTRICAL ENGINEER to the Bradford Corporation.

The person appointed is required to assist the City Electrical Engineer and Manager in all engineering matters, but principally in connection with the generation and distribution of electrical energy.

Applicants must have received a sound technical education, and have practical knowledge of the design and operation of electrical generating and converting plant and transmission and distribution systems.

The salary attached to the post will be from £750 to £1000 per annum, and candidates are requested, in making application, to state the salary required.

The successful candidate will be required to devote his whole time to the duties of the office, and to reside within the City.

Canvassing members of the Council (either directly or indirectly) will be a disqualification.

Lists of Duties and Forms, on which applications are to be made, may be obtained from Mr. THOMAS ROLES, City Electrical Engineer and Manager, Town Hall, Bradford.

Applications, endorsed "Deputy City Electrical Engineer," accompanied by COPIES of not more than three testimonials (which will not be returned), to be sent in time to reach me not later than the first post on Tuesday, the 29th August, 1922.

E. L. FLEMING, Town Clerk.
Town Hall, Bradford, 8th August, 1922. U 92

DAM CONSTRUCTION IN AMERICA.

THE very large water resources of America still undeveloped, are causing much attention to be devoted there to the design of large retaining dams. The orthodox type which originated in the researches of M. M. Graeff and Delocre, is in many cases being widely departed from, very bold and striking expedients being adopted with a view to reducing costs of construction.

A highly interesting project recently described by Mr. E. C. la Rue, in the Proceedings of the American Society of Civil Engineers, involves the formation of an enormous reservoir on the Colorado River near Lee Ferry by a dam no less than 700 ft. high above normal water level. The flow at this point for eight months in the year ranges from 4,000 cub. ft. to 10,000 cub. ft. per second, but during the remaining four months flood discharges of more than 147,000 cub. ft. per second have been recorded. The river here flows in a canyon of which the side walls are 1,300 ft. high, the width at the bottom being 450 ft., whilst at crest level the dam would be some 1,200 ft. to 1,300 ft. long. The volume of water impounded by this wall is estimated at 50,000,000 acre-ft., of which 20,000,000 acre-ft. would be above the 600-ft. level. Assuming that the water level need not be drawn down below 600 ft., this would make the average head available for power production to be 650 ft., and it is estimated that 1,000,000 h.p. could be continuously developed. The canyon takes a sharp S curve bend in the neighbourhood of the proposed dam, so that by tunnelling through 3,000 ft. of rock, the stored water could be led to a power station situated 6 miles below the dam, as measured along the river bed. The mean flow available for power production is stated at 19,300 cub. ft. per second, and the tunnel is to be 30 ft. in diameter. A concrete dam it is estimated would cost not less than 50,000,000 dols., and hence plans have been considered for a rock-fill dam to be made by blasting into the canyon the upper portions of the side cliffs. It is proposed to arrange matters so that the first blast shall fling into the canyon 20,000,000 cub. yards of rock, which would be rendered sufficiently water-tight by sluicing small material into the interstices. The total cube of the dam when raised to the 700-ft. level will be 50,000,000 cub. ft., and its length on the axis will be 5,690 ft. from the up-stream toe to the down-stream toe. The up-stream slope is to be 3 to 1, and the down-stream from 4 to 1 in the upper part to 6 to 1 in the lower. Save in the upper portions it is thought that very little handling of the rock will be required. The estimated cost is little more than half that of a concrete dam.

The design of arched dams is another subject which has recently been discussed before the American Society, but this appears to have contributed little that was not brought out in the discussion before our own Institution of Civil Engineers in 1909. Several of those who took part in the discussion in America expressed the opinion that much might be learnt by measuring the deflection of existing arched dams. This view, however, is hardly confirmed by Australian experience, which seems to show very conclusively that such structures do not act as if perfectly elastic. It has been a common practice to proportion such dams as if they were complete cylinders exposed to an external water pressure, and to assume that the whole of their resistance is due to arch action. This assumption seems to have proved satisfactory in practice, although, since the base of the hypothetical cylinder is *encastré* into the ground there can be little or no arch action at this level. The problem of the distribution of stress in an elastic cylinder thus fixed can be solved without much difficulty, save of a merely arithmetical kind. The results, however, show very clearly that the assumptions of the mathematical theory of elasticity are inapplicable. Such a calculation indicates the existence of enormous bending stresses near the base of the dam, far in excess of the strength of the material. Nevertheless such dams have so far proved quite successful, which is no doubt to be attributed to the fact that most of our materials of construction are capable of taking without failure considerable plastic deflections. Even old brick walls built in common mortar are no exception to this rule. The Australian observations also showed that the deflections appeared to be governed rather by temperature changes than by the stresses, and that the shape of the deflection curve did not agree with that calculated from the mathematical theory of elasticity. Of course, no arched dam is ever a complete cylinder, but abuts on the rocks at the sides of the valley in which it is located. This complicates the mathematical theory, but on the assumption that the deformations are elastic the stresses can, given sufficient patience, still be calculated by known methods, but there is little reason for believing that the values thus found form any criterion of the safety of the structure. This feature has probably played no small part in restricting the use of the type, in spite of successful precedents nearly 100 years old. Few engineers, indeed, are sufficiently bold to discard computed stresses, when these are in disagreement with experience. To most a stress is a stress, and is considered equally serious, whether the structure be statically determinate or the reverse. The Australian method of treating such structures as rings resisting entirely by arch action is, no doubt, as crude as it is simple, but we know that under steady stresses a statically indeterminate structure is generally safe, provided it appears safe on any reasonable hypothesis as to stress distribution that we may care to adopt. In America it appears that the Australian method is often barred by political considerations, and a case was mentioned in the discussion where, although the plans for an arched dam 90 ft. high had been approved by a competent board of consulting engineers, the real indeterminateness of the stress, made it possible for a "political filibuster" to so frighten the community affected, that the height had to be cut down to 30 ft.

Another interesting development in the United States is the use of syphon spillways in place of the ordinary by-wash. The type is said to have originated in Lorraine nearly forty years ago, and a number have been constructed in different parts of Europe. Of late years the system has been used in the states not infrequently. The syphon is constructed in the concrete of the dam itself, and as it may work under a head of 30 ft. or more, the discharge per unit of length occupied is much greater than with an ordinary spillway, where the effective head may not exceed a few inches. An air passage is provided to the bend of the siphon, the opening to which is on the up-stream side at the same level as the bend. This is sealed by the rise of the water when a flood occurs, but is uncovered when the water falls again. Air is thus admitted to the bend of the syphon, and the latter ceases to operate accordingly. One danger to be guarded against is that in cold weather if the rise is insufficient to prime the syphon, the excess water will simply trickle through and may freeze, so that the whole passage may be blocked with ice, and if a heavy flood then occurred the dam might be topped.

THE LJUNGSTRÖM TURBINE LOCOMOTIVE.

(*Continued from page* 133.)

THE CONDENSER.

THE success of any form of turbine locomotive is intimately bound up with the provision of a suitable condenser, as the economy of the turbine depends so largely upon the vacuum into which it exhausts. The problem of designing a portable condensing plant to deal with anything up to about 20,000 lb. of steam per hour, yet kept strictly within certain limitations of size and weight, is by no means an easy one. Certain inventors have adopted the evaporative principle, the steam passing through thin tubes cooled by the evaporation of water trickling over them. This method involves a serious loss of water, as every pound of steam condensed will cause the evaporation of about an equal weight of the cooling water. Messs. Ljungstrom realised the very strong practical objections to the consumption of so large a quantity of cooling water, and determined that direct cooling by means of air was the ideal to be aimed at. Their condenser therefore embodies this principle which is carried out with great mechanical courage and ingenuity, as will be evident from a study of the design.

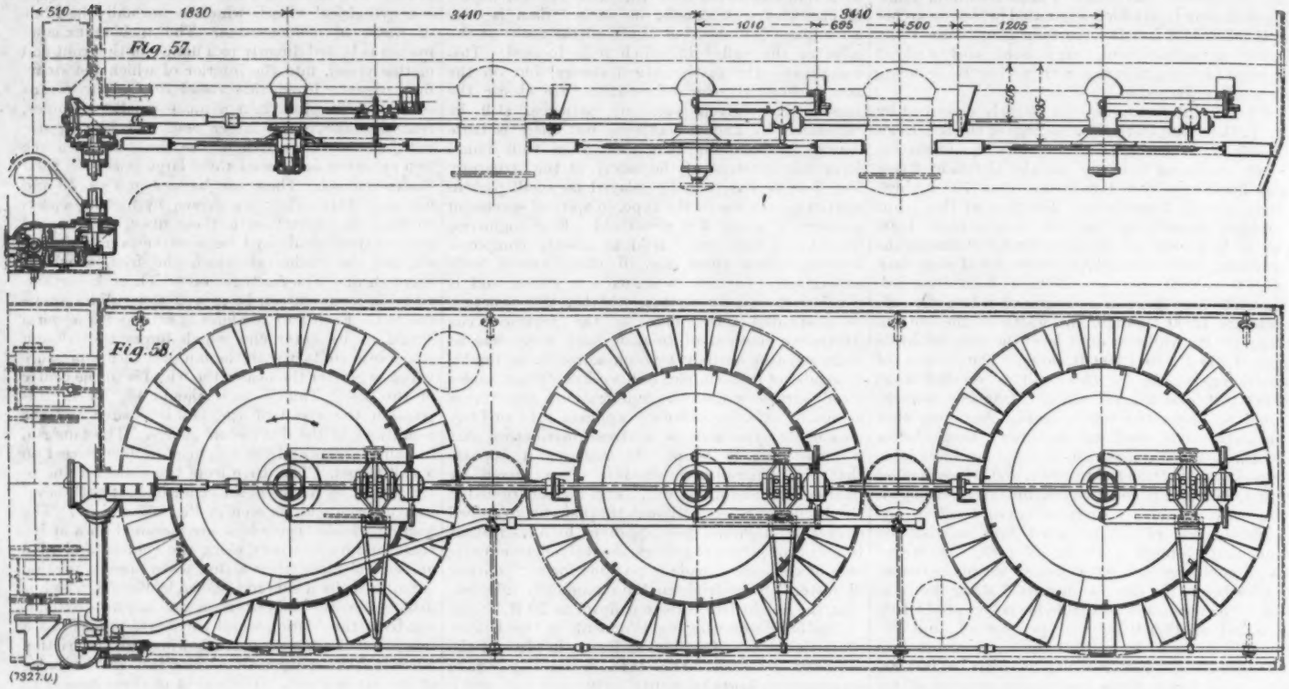
Except for the very small amount of room taken up by the turbine and gearing, the condenser occupies the whole of the engine-car, as will be seen from Figs. 3, 4 and 5, Plate VIII *ante*. In the interior of the car, and running the full length of the body, is a cylindrical vessel, which is normally half-full of water of condensation. The turbine exhaust branch is bolted directly to a flange on the front end of this vessel, into the interior of which the steam first passes. From this vessel it rises by means of two short pipes into a much smaller cylinder, centrally above the larger one, and like it also running the full length of the car. Between the two cylinders are placed three large fans with their shafts vertical. These can be seen in Figs. 58 and 60, page 164. They are driven by friction wheels running in contact with their discs, their speed being varied as desired between certain limits by altering the radius at which the friction wheels drive them. The carriage on which each friction-wheel is mounted can be moved along slides above the fan. Each pair of slides is fitted with a spiral spring at its outer end which forces the friction wheel into contact with the fan disc with a pressure which is greater the nearer the wheel is to the centre of the disc. This is as it should be, for in this position the speed of the fan is greater and the conditions of the drive more severe. The fans run in ball bearings and the weight of each is carried on a ball thrust. The drive from the main turbine to the fans is by means of an inclined shaft with bevel gear at each end, as seen in Figs. 57 and 59. The friction-wheels themselves are mounted on a spline shaft running centrally along the vehicle, and they are moved along their slides, when speed variation is required, by a side rod shown in Fig. 58, which is attached to the ends of triangular brackets extending from the friction-wheel carriages. Fig. 61 is a near view of a fan support, showing also the friction wheel and the spline shaft running through the centre of the fan support. The object of these fans is to induce a strong current of air over the lower cylinder and particularly upward between the copper elements wherein the greater part of the condensation of steam is effected. Each fan delivers 40 cubic metres of air per second. The sides of the vehicle are composed of vertical curved guide-plates which facilitate the entrance of the air when the locomotive is running. Their general appearance will be understood from Fig. 1, on page 65 *ante*, and their shape from Fig. 6, Plate VIII *ante*. Their curvature was decided on in accordance with the results of a series of experiments carried out with a wind-tunnel at Messrs. Ljungstrom's works, and their form is such as to give the most effective entrance to air when the vehicle is in motion.

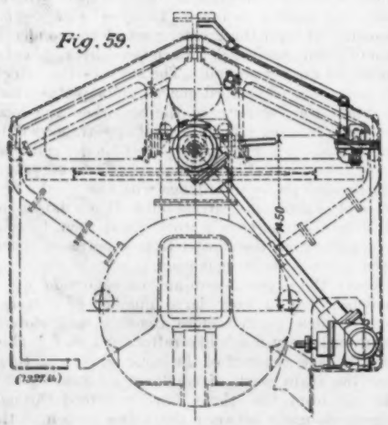
Above the drums, there are, on each side of the condenser car, a very large number of flattened copper tubes packed close together and sloping downwards very much like rafters of a roof. They form, in fact, the roof of the car, and it is in them that the main work of condensation takes place. The air from the three fans is forced through narrow channels between the tubes, which in the aggregate have a cooling surface of 1,000 sq. metre. The arrangement of these tubes, relative to the rest of the car, is seen in Figs. 10 and 11, page 65 *ante*, and details of their construction are given in Figs. 62 to 68, on page 165. Along the top of the upper drum are two rows of copper boxes held in position by cramps, as shown in Figs. 62 to 64. These boxes are made from copper tubing, in eight operations, the tangs being first pressed down to the required diameter, the large end then being closed and welded, the squared portion then shaped and the spigot end finally turned to size. On one side of the squared part are six long narrow slots, into which the ends of the condenser tubes are brazed. Opposite these slots is a window, as shown in the left-hand detail of Fig. 65. This window is finally closed by having a plate of similar size brazed into the recess round the opening.

The condenser tubes, the nature and proportions of which will be understood from Figs. 65, 67 and 68, are made from copper tubes 0·75 mm. thick. These tubes are first flattened by hand, and are then threaded with a steel straight-edge about 1·7 mm. thick, and pressed tightly on to it in a guillotine press. The next operation is to form the raised

THE LJUNGSTRÖM TURBINE-DRIVEN LOCOMOTIVE.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.





ribs which are seen on the outside of the flattened tubes. The method of doing this is most effective, yet extraordinarily simple and cheap. The tube, with the steel straight-edge inside it, is put under a punching machine, fitted with tools illustrated in Fig. 69, page 166. This machine carries two pairs of heavy dies, pivoted at their outer ends, so that the adjacent inner ends approach each other when pressure comes upon them. The action resembles that of a toggle. Each of the dies is attached to a plunger, which cannot be seen in the illustration, and the dies can only close together by moving these plungers against an oil pressure acting on the plungers. The free ends of the dies terminate in hardened sharp steel edges.

When the copper tube is put into the machine and the latter is started, the upper dies descend and the knife edges bite into the copper with considerable force, because the hydraulic pressure acting against the dies prevents them closing easily. When the pressure on the copper exceeds a pre-determined amount, the hydraulic pressure is overcome and the toggle action of the dies takes place. The knife-edges then approach each other and scrape up the surface of the copper into a sharp fin between them.

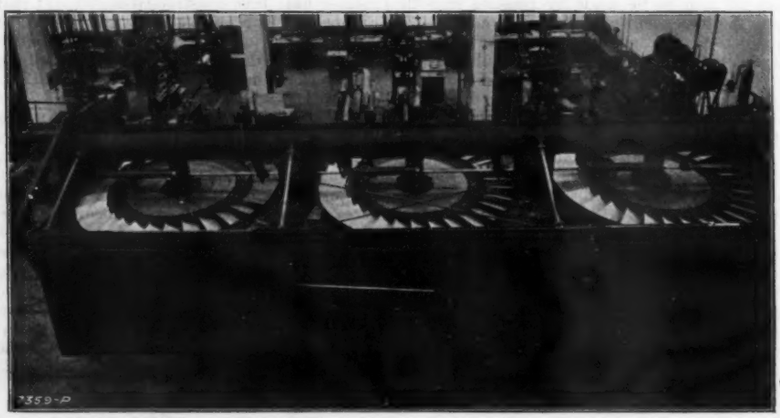


Fig. 60.

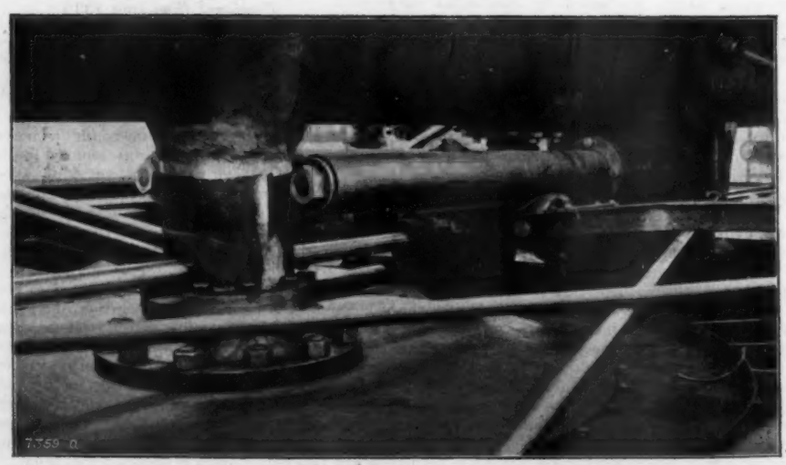
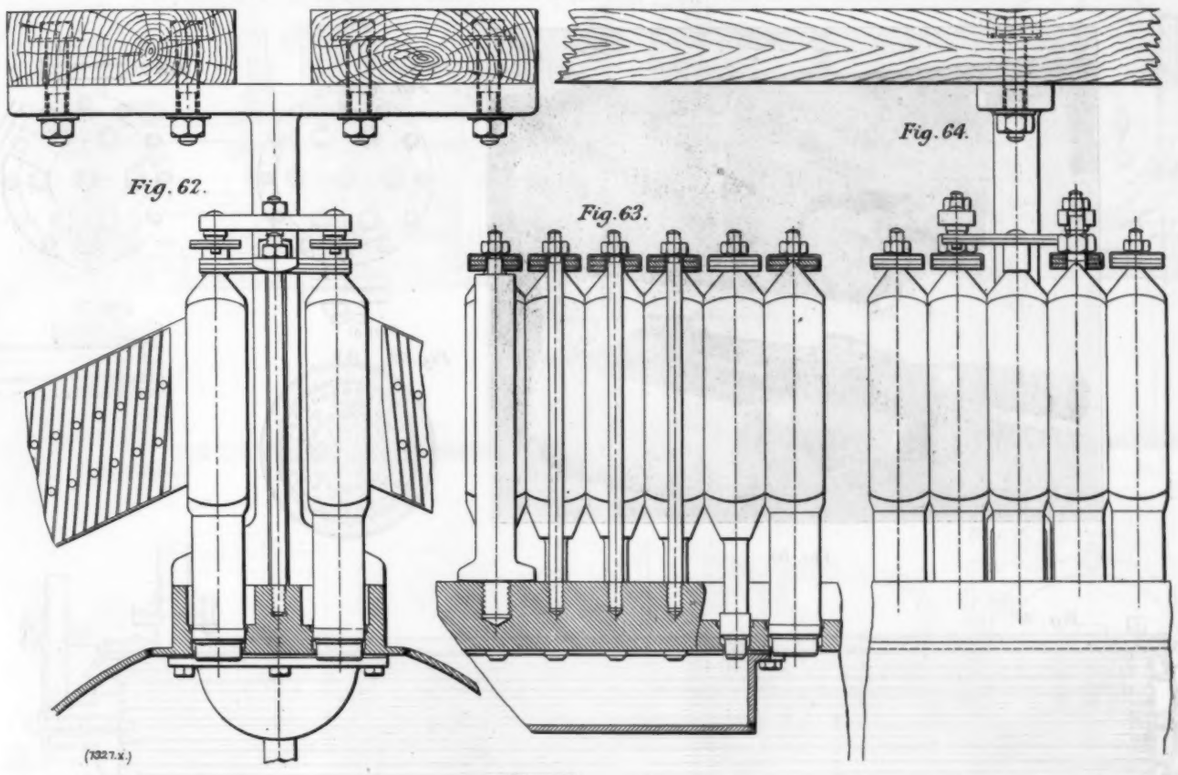
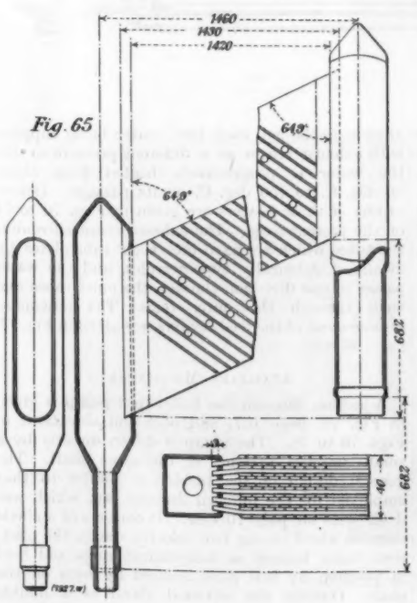


Fig. 61.

THE LJUNGSTRÖM TURBINE-DRIVEN LOCOMOTIVE.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.





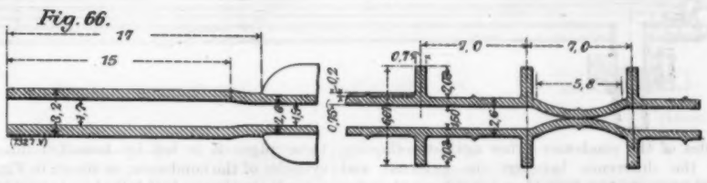


FIG. 67.

FIG. 68.

A precisely similar action takes place with the lower fixed pair of dies, and the flattened copper tube thus has a fin produced upon its upper and lower surfaces respectively. On the return stroke of the machine the copper tube is fed forward by a certain amount, and when the next down stroke is made another pair of fins is formed parallel to the first. By a comparison of Figs. 62 and 65, it will be noticed that when the copper condenser tubes are arranged in their working position, the fins on one run at right angles to those on the adjacent one. The plan view in Fig. 65 shows that the tubes are packed together as tightly as possible sideways. The air which is forced between them by the fans thus has to pass along numerous very small channels between the fins, and is caused to eddy by the edges of the adjacent fin as these lie at right angles to its path. The conditions are, therefore, as perfect as possible for the air to abstract heat from the cooling tubes. Six of these tubes are brazed into each of the rectangular copper boxes which carry them, and each group of six tubes has an overall width exactly equal to that of the box. The boxes are mounted in contact with each other, and the air, therefore, has no way of escape except by passing through the narrow channels formed by the fins on the sides of the tubes.

The fins, of course, do much to strengthen the

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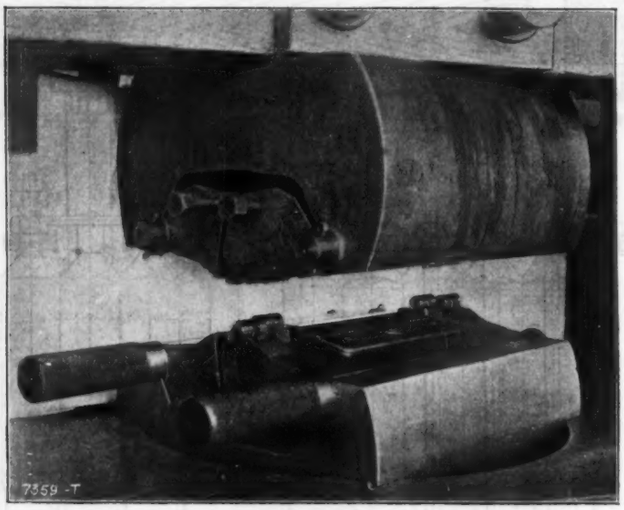
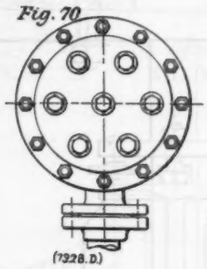
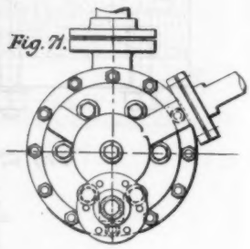
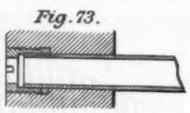








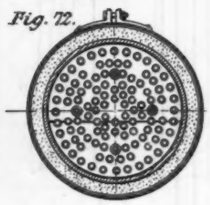
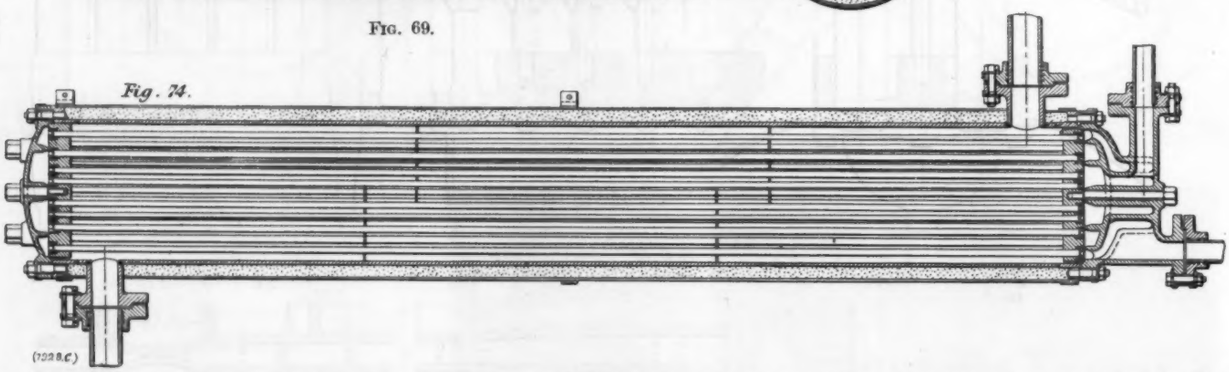


FIG. 69.



flat sides of the condenser tubes against collapsing under the difference between the external and internal pressure to which they are subjected under working conditions. But a further simple and ingenious device has been adopted to avoid danger of collapse. In Figs. 67 and 68 will be seen a pair of small circular depressions between alternate pairs of fins. At these points the sides of the tubes are punched inwards, so that small rounded projections are formed on the inside. When the external pressure on the tube is greater than the stiffness the sides can withstand, these projections come into contact with each other and no further movement can take place. To make these depressions, a steel straight-edge, having two longitudinal grooves down each face, is inserted in the tube. This supports the walls, except along the lines where the depressions are to be made. The machine for making the depressions consists merely of a couple of rollers having helical teeth, which engage with the fins on the tubes and feed the latter through when the rolls are turned. At two places along the rollers the teeth are cut away and every alternate tooth is replaced by a peg. As the copper tubes are drawn through the rolls, these pegs indent the two surfaces and so produce the depressions which we have described. Fig. 66 shows an enlarged section through one of the tubes, and illustrates the proportions of the fins and of the depressions. The small sharp-edged ridge between the fins is the metal left untouched between the dies of the punching machine when the ribs are formed.

Returning now to the action of the condenser, the steam passes from the upper rows of boxes to the lower rows through the interior of the flattened tubes, being condensed into water on the way. The condensate drains from the lower boxes into horizontal pipes running lengthwise of the car and from these pipes it is led by branches into the large cylinder of the condenser, as shewn in Fig. 59. This cylinder is always half-full of water, which not only forms a reserve for boiler feeding, but which also serves to equalise the work of the condenser, and to enable the plant to deal with heavy overloads of steam for a short time. When the locomotive has been stopped, or has been working at less than full load for some time, the water in this drum is comparatively cool, and as the exhaust steam from the turbine comes directly into contact with it, the presence of so large a volume of cool water gives a reserve capacity to the condenser which is very useful when the locomotive is called on to exert its maximum power. To make this water more effective, it is brought into intimate contact with the steam from the turbine by means of a centrifugal pump and spraying arrangement. Reference to Fig. 4, Plate VIII *ante*, will show that the shaft of the central fan is continued downwards and terminates in a pump impeller beneath the surface of the water. This impeller runs in a cylinder with an opening in the bottom opposite the eye of the impeller. The water is drawn in at this point and delivered over the edge of the cylinder, whence it falls on to an iron grating above the surface of the water. The grating is thus kept cooled so that it acts as as condensing surface and the water dripping through it in a finely divided state is mixed intimately with the steam.

Water for boiler-feed purposes is withdrawn from the condenser by means of a condensate pump driven by a steam turbine and delivered to a boiler-feed pump, also turbine driven, which forces it into the boiler. In future designs we understand it is intended to perform both these functions by a single pump. The feed pump delivers the water through three-feed water heaters in series, as already explained, each feed heater being supplied with exhaust steam at a different pressure so that the water is progressively heated from about 50 deg. C. to 150 deg. C. on its passage. Details of one of these heaters are given in Figs. 70 to 74 on the present page. The exhaust steam surrounds the tubes which are fixed into their tube-plates by means of Admiralty type ferrules, and the water passes in one direction through the inner tubes and back through the outer ones. The schematic arrangement of the feed-heaters was given in Fig. 13, page 66 *ante*.

Auxiliary Machinery.

A section through the boiler feed pump is given in Fig. 75, page 167, and plan and elevations in Figs. 76 to 78. The pump is driven directly by a small impulse turbine on the same shaft. The general design of the turbine is similar to that employed for the induced draught fan, which was dealt with on page 70 *ante*. It consists of a single impulse wheel having two velocity stages, the blade rows being formed as independent rings and held in position by side discs secured by nuts on the shaft. Outside the external gland is a double cooling disc to prevent the heat of the steam affecting the adjacent bearing. This bearing is of the plain type lubricated by oil under pressure which is led to the interior of the shaft end by the pipe shown. The shaft is flexible, and is located endwise by a collar at the pump end. Adjacent to this collar is the worm which drives the vertical shaft of the lubricating pump, this pump being submerged in an oil tank of comparatively large size, formed in the bedplate. The boiler feed pump has three impellers in series, and has forced lubrication to both its bearings. This pump, of course, has to deliver against the boiler-pressure of 300 lb. per

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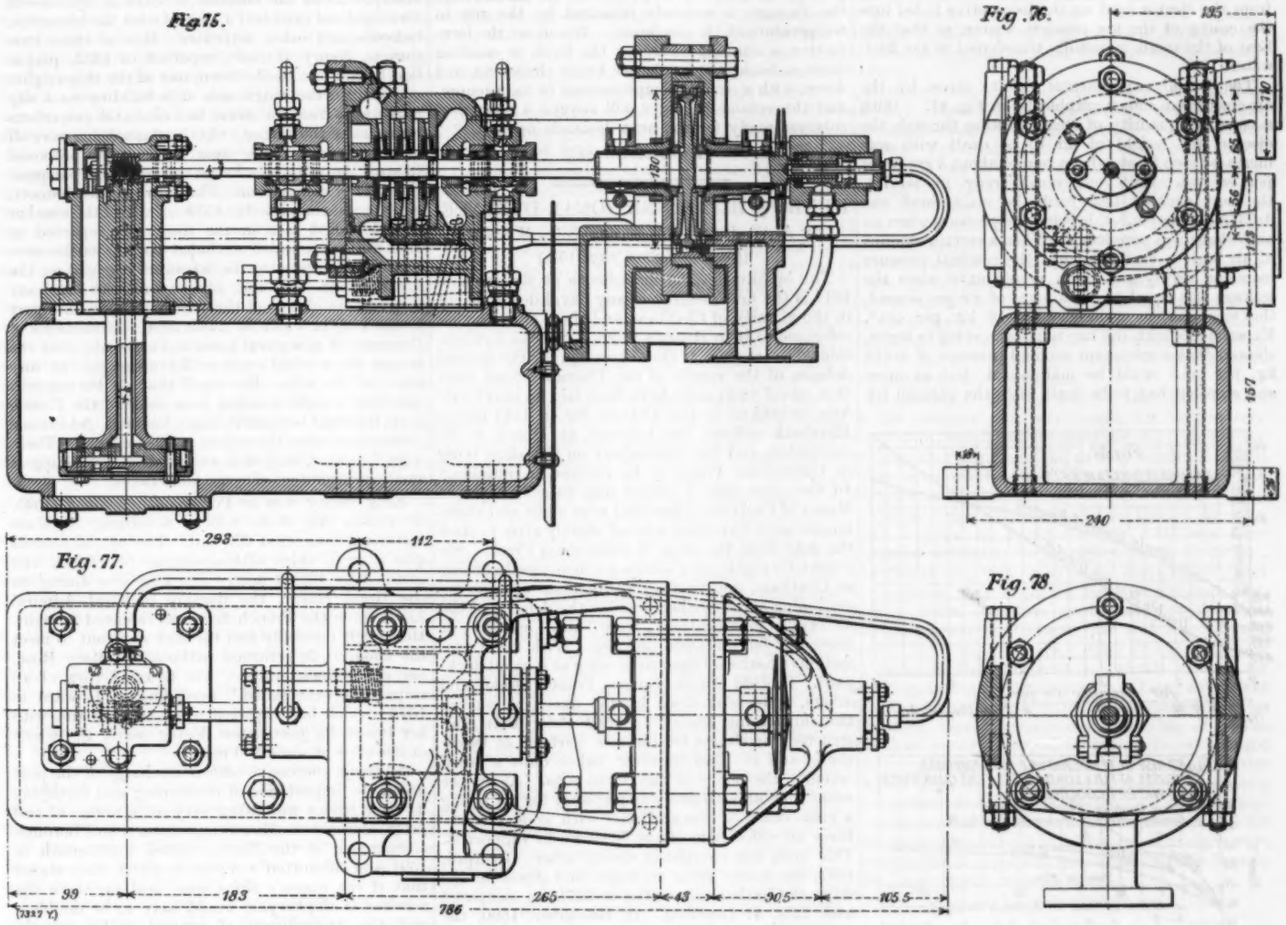


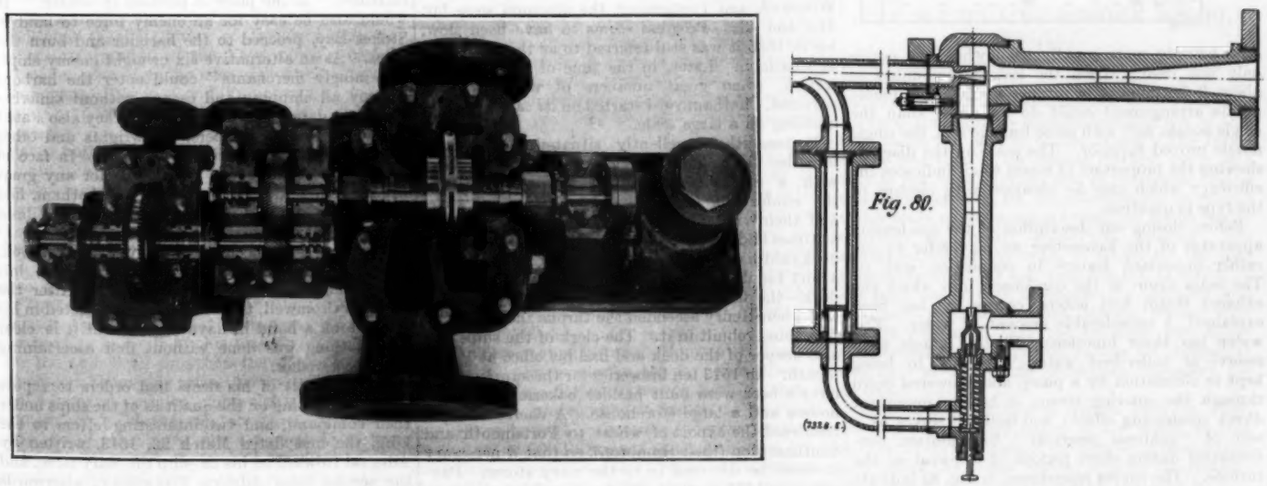


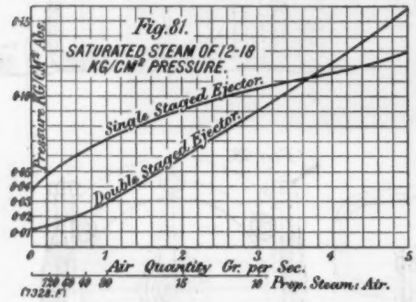
FIG. 79.

square inch, in addition to the resistance of the three feed heaters in series.

Fig. 79 illustrates the condensate pump. This again is driven by its own steam turbine, but on account of the comparatively low head against which it has to work a single-impeller is all that is necessary, and this is driven by helical reduction gear from the turbine spindle. The arrangement is so clearly shewn in the photograph that no detailed description is necessary. The air is extracted from the condenser by means of the air-ejector shown in Fig. 80, annexed. The lower flanged branch, facing to the right in the drawing is connected to the condenser. Steam at boiler pressure enters by the upper pipe on the left. Part of the steam passes straight along through the horizontal ejector and part passes down through the branch shown and then through the vertical ejector. The amount of steam taking the latter course is controllable by the needle-valve shewn. The vertical ejector acts first on the air from the condenser, and delivers it to the space around the nozzle of the horizontal ejector, so that, so far as the work of extracting air is concerned, the two ejectors work in

series. Very exhaustive experiments on air extractors of this type have been made by Messrs. Ljungström with results which confirm the view that a properly designed air ejector can be an extremely efficient and reliable apparatus. The discharge from the ejector used on the locomotive is led into the casing of the low-pressure heater, so that the heat of the steam is usefully transferred to the feed-water.

The actual experimental results given by the air ejector are shown graphically in Fig. 81. With a constant quantity of steam passing through the ejector, the weight of air to be dealt with was increased step by step from zero to about 5 grammes per second. With one nozzle only in service, the best vacuum that could be maintained was 0·0375 kg. per cm.², this being the pressure when no air leakage was permitted. When a certain amount of air had to be dealt with, the residual pressure increased slowly and fairly evenly until when the leakage was equal to 5 grammes of air per second, the vacuum was reduced to 0·16 kg. per cm.². Experiments with the two nozzles working in series, showed that a minimum residual pressure of 0·012 kg. per cm.² could be maintained, but as more and more air had to be dealt with, the vacuum fell



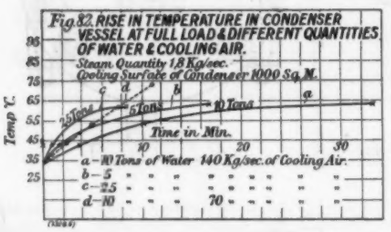


Fig. 82. RISE IN TEMPERATURE IN CONDENSER VESSEL AT FULL LOAD & DIFFERENT QUANTITIES OF WATER & COOLING AIR.
Steam Quantity 1.8 Kg/sec.
Cooling Surface of Condenser 1000 Sq. M.
Temp °C.
Time in Min.
a—10 Tons of Water 140 Kg/sec. of Cooling Air.
b—5 " " " " " " "
c—2.5 " " " " " " "
d—10 " " 70 " " " "

off relatively more rapidly than when one nozzle only was used. When the leakage amounted to about 3·7 grammes of air per second, the double nozzle arrangement could do no better than the single nozzle, and with more leakage still, the single nozzle proved superior. The scale on the diagram showing the proportion of steam to air indicates the efficiency which may be obtained with ejectors of the type in question.

Before closing our description of the condensing apparatus of the locomotive we may refer to one rather important feature in connection with it. The main drum of the condenser, into which the exhaust steam first enters, carries, as has been explained, a considerable amount of water. This water has three functions. Firstly, it acts as a reserve of boiler-feed water; secondly, by being kept in circulation by a pump and showered down through the entering steam, it has an important direct condensing effect; and lastly, it serves as a sort of "coldness reservoir" to maintain condensation during short periods of overload on the turbine. The curves reproduced in Fig. 82 indicate its value in this respect. They show the rate at which the temperature of the condenser, which depends of course upon that of the mass of water in the drum, rises as time goes on. For all the tests the rate of condensation is 1·8 kg. of steam per second or about 14,250 lb. per hour. With the condenser fans delivering 140 kg. of air per second, and the condenser at an initial temperature of about 33 deg. C., the temperature of the condenser will never exceed 65 deg. C., which corresponds to a vacuum of about 24·25 in. of mercury. With the drum, however, containing its normal amount of 10 tons of water the vacuum only approaches this limit after more than 35 minutes, so that a run of a good many miles at full power may be made before the vacuum is seriously impaired by the rise in temperature of the condenser. Whenever the locomotive is running easily on the level, or coasting down a bank, the condenser has a chance to cool down, with a resulting improvement in the vacuum, and the volume of water will acquire a reserve of coldness ready for the next demands upon it.

(To be continued.)

HENRY VIII AND NATIONAL DEFENCE.

By A. W. Johns, C.B.E., R.C.N.C., M.I.N.A.

(Continued from page 153.)

The building of the mast-house at Rainham in 1514 is the first mention of any naval development in the vicinity of Chatham, and there is no further reference to it in Henry's reign. In 1545 fortifications were erected at Queenborough for the general defence of the mouth of the Thames. Soon after this, naval units must have been laid up near Chatham instead of in the Thames, for in 1561 Queen Elizabeth ordered the bulwark at Upnor to be completed, and the shipkeepers on the ships lying in Gillingham Water to be reduced in number.* In the same year a survey and valuation of the Manor of Chetham (Chatham) were made and storehouses must have been started shortly after to stow the gear from the ships in Gillingham Creek. Six years later eight queen's ships are mentioned as being at Chatham, and in 1572 an estimate appears for stationing ships at Sheerness for the defence of the Medway. Fortifications were also erected at Sheerness for the same purpose. With these protections Chatham began to develop as a naval dockyard. In 1581 Cotton, Gorges, Francis Drake, and others, were sent down by the queen to survey the ships lying there. In 1583 Peter Pett constructed the sluices for the new harbour at Dover there, and in 1586 Matthew Baker built a small warship, the Sonne or Sun, of 50 tons. About the same time an estimate was prepared for supplying a great chain of iron at Upnor with wooden structures on either side of the Medway to support it. This work was completed shortly after. In April, 1593, the money spent on wages and stores for the ships at Chatham amounted to 517*l.*, as compared with 223*l.* at Deptford. In December, 1590, the corresponding sums were 564*l.* and 96*l.*, whilst at Woolwich and Portsmouth the amounts were but 31*s.* and 43*s.* Progress seems to have been slow, for in 1625 it was still referred to as the new yard at Chatham. Later, in the time of the Commonwealth, when great numbers of warships were required, Chatham yard started on its career of shipbuilding on a large scale.

Portsmouth, excellently situated as a base for the fleet guarding the narrow seas, and with a fortified Isle of Wight in front, was the rendezvous for the king's ships in war time, and their victualling port. There the units were at times laid up instead of in the Thames. A small dockyard had existed there since 1212, and in 1418 a fort for its defence was erected. In 1495 a dry dock—the first in the kingdom—was constructed, and when Henry ascended the throne the Sovereign was being rebuilt in it. The clerk of the ships was also keeper of the dock and had his office at Portsmouth. In 1513 ten breweries for the supply of the navy's beer were built besides bakeries, slaughter houses and a large storehouse. A decree of 1512 restricted the export of wheat to Portsmouth and Southampton (then Hampton), so that if necessary it could be diverted in to the navy stores. Payments in 1514 mention 40*l.* for "making chains to draw over the haven" and "four boats for bearing the chains" at 8*d.* a month. In 1522 the wages to shipwrights and others on the king's ships amounted to 450*l.*; pitch, oakum, tallow and iron cost 100*l.*; cables and ropes, 1,000*l.*; and anchors, 100*l.*; all large sums, and showing considerable activity at the port. In 1530 appears a payment for wages and material for building a wall for enclosing "nine acres bought for the king, on which storehouses and docks are made."

Financially, Portsmouth was an appanage of Hampton, and the customers—custom officers—of its neighbour exercised a control over the breweries, bakeries and other activities. One of these customers, Henry Huttoft, reported in 1537, plague had broken out in the town, one of the shipwrights engaged on the king's new ship building on a slip half a mile from the town, had died and two others were sick of the plague. As the shipwrights were all lodging in one house near the slip he proposed to stop the work, discharge the men and postpone the date of completion. The ship was the Jennett, of 200 tons, completed in 1539. In 1544 the number of ablebodied men in the town was reported as 100, but this number excluded 400 to 500 brewers and bakers, and also the labourers engaged on the fortifications. In the same year Sir Anthony Knyvett, in charge of the port, submitted a report to the king in which he dwelt on the advantages of Portsmouth as a naval base, and especially that the largest ships could enter or leave the port at any state of the tide. He urged that as Portsmouth was only a night's sailing from some of the French ports it should be more strongly fortified. Additional protections were thereupon taken in hand. These were, however, only of a weak nature, consisting of earthworks protected by wooden stakes.

King Henry was at Portsmouth in July, 1545, to review his fleet, which, according to some historians numbered 200 sail. The official records give it as 57 ships with a tonnage of 14,000, and manned by 10,000 men. The king was dining on the Great Harry, the flagship of Lord Admiral Lisle, when the French fleet was reported in sight. Henry left hurriedly and his fleet went out to meet the enemy. It returned without the Mary Rose, one of its finest units—"the flower I trow of all ships that ever sailed," according to Howard in 1513—which had capsized when tacking and with her lowest lee ports open, losing nearly the whole of her crew of some 500 men.

Although successive officers in charge of the port urged the importance of developing and fortifying it, their advice was taken very little notice of and progress was slow. Hawkyns, treasurer and Borough comptroller of the Navy, visited Portsmouth in 1591 and submitted a report in which they stated that if the queen's ships were laid up there the number of shipkeepers would have to be doubled, and the expenditure of ground tackle greatly increased "as the place is perilous in winter." It would also be easy for an enemy force to land in Stokes Bay, proceed to the harbour and burn the ships. As an alternative six or eight enemy ships, "seemingly merchants" could enter the harbour destroy all shipping and escape without suffering any great damage from the forts. They also stated that very few shipkeepers, shipwrights and other mechanics were available at the port. In face of such a report there was little hope for any great developments, and Portsmouth, like Chatham, had to wait until the Commonwealth to be utilised to the extent it deserved.

The king's Chancellors, Wolsey and Cromwell, superintended most of the affairs of State, but Henry himself looked after his Navy. After the death of Cromwell, the Privy Council, elected in his stead, took a hand in naval affairs, but it is clear that nothing was done without first ascertaining the king's wishes.

The admirals of his fleets had orders to report direct to the king on the qualities of the ships under their command, and two interesting letters to the king, the first dated March 22, 1513, written by Admiral Howard on his flagship the Mary Rose, and the second from Admiral Fitzwilliam, afterwards Earl of Southampton, and Lord Privy Seal, dated May, 1522, from the Great Harry, are preserved in the State Papers. Both give details of sailing trials carried out to test the sailing powers of the ships in their fleets, and show that the Mary Rose and Sovereign were two excellent sailers, the Great Harry was nearly as good, and that all were far better than the Venetian and Genoese caracks which the king had purchased. Henry himself had some original ideas on ship design and other nautical

* Gillingham Water was the portion of the Medway now named Chatham Reach.

matters. In April, 1523, Fitzwilliam, then at Portsmouth, reported to the king "The galley is in dock and Brigandine intends to build her carvel so she shall now be made in every way as your grace, devised." The French Ambassador wrote to his Government in July, 1541, "The king has sent to Italy for three shipwrights expert at making galleys, but I think now that he will not need them as he has begun to make ships with oars, of which he himself is the architect." Nevertheless the Italians were employed, and as a result the Galley Subtill of 300 tons burthen, and with a crew of 250 men, was built and, presumably, to the king's design. She did good work in the Scotch and French wars. Five years later the Ambassador wrote that the king was building some galleons of a new type. Knyvett at Portsmouth informed Henry in 1544 of the arrival of ships from the Thames with buoys and cables "by your majesty devised for the haven here." A report from Comptroller Spert and Treasurer Gonson, in 1540, states: "We understand the king is determined to buy certain masts from Thomas Gigges. His majesty may be pleased to write to the town of Dansyke (Dantzic) that they be for his use as he did in the receipt of the last masts." There are also reports from William Watson, at Dantzic and William Danesell at Antwerp, buying stores at these places during the French war, which show clearly that the king himself had given them detailed instructions as to the purchase of anchors, cables and masts, and that no departure was to be made without his consent. Other instances might be added, but sufficient has been quoted to show that the king possessed an intimate knowledge of his ships and their requirements.

In the previous reign and later in that of James I* a bounty of 5*s.* a ton was paid to the owners of newly-built merchant ships to encourage the growth of the mercantile marine. There is no trace of a similar bounty in Henry VIII's reign, so that it may be concluded it was not necessary. The king's purchase of several of the largest merchant ships† for his Navy indirectly encouraged shipbuilding, but a more direct incentive was given by an Act of 1540, by which all oversea exports and imports had to be carried in English bottoms. This caused considerable irritation on the Continent, and protests were made and similar acts passed by the other naval powers, which resulted after a time in some modifications in the English Act.

To encourage the art of navigation the king granted a licence in 1513 to the "Masters, Rulers and Mariners of the King's Navy in the Thames," to found a guild in honour of the Holy Trinity and St. Clement in the Church of Deptford Stroude "for the reformation of the Navy much decayed by the admission of young men without experience, and of Scots, Flemings and Frenchmen as lodesmen" (*i.e.*, pilots). In May of the following year the licence was extended to "the Mariners of England, both men and *women*," the brethren of the guild to appoint one master, four wardens and eight assistant wardens annually, all of whom shall be removable at pleasure." A mortmain licence was also granted to acquire lands to the annual value of 20 marks (13*l.* 6*s.* 8*d.*) for a chaplain to the guild. Thus was instituted the Brethren of Trinity House, a corporation whose functions were extended by Elizabeth and Charles I. In May, 1635, an Admiralty Order stated that "when any ship shall be ordered to be built for his majesty, the officers of the Navy shall call unto them the ablest of the sea commanders about this town, his majesty's master attendants and master shipwrights and their assistants, some of the chief brethren of Trinity House and of the Shipwrights Company belonging to the Thames, and they shall consider all fit dimensions and shall submit them in writing to the Lords of the Admiralty." Trinity House was also partly responsible for the measurement of tonnage and for the ballasting of ships.

In 1536 a licence was granted to some shipowners and seafaring men of Newcastle to found a fraternity or guild of mariners and other persons in honour of the Holy Trinity at Newcastle. A master and four wardens, with the brethren and *sisters*, were to make laws for the navigation of the port of Tynemouth, the preservation of order among the mariners and for maintenance and continuance of the said port were to build and fortify two towers on the north side of "le Shelys." A third tower was to be erected on a hill for "signals, metes and bounds" for the safe keeping of the town and port. The guild was given power to collect 4*d.* from every foreign, and 2*d.* from every English ship, entering the port for keeping the towers perpetually lighted at night. In Elizabeth's reign there was continuous trouble between this guild and the mayor and corporation of Newcastle.

The time of the merchant adventurers had not yet arrived. They were to flourish in and add lustre to Elizabeth's reign. One of their forerunners, William Hawkyns, of Plymouth, made voyages to Brazil in 1530 and 1532, and was considering a third voyage in 1536. In that year he wrote to Cromwell requesting the king to lend him four brass pieces of ordnance and one last (2,400 lb.) of gunpowder on good securities, and also on a security of 100*l.* a loan of 2,000*l.* for seven years towards equipping three or four ships, and "I doubt not to do such feats of merchandize as shall be of great advantage to the king's custom." It is not stated if the guns or money were lent him, but Hawkyns proceeded on his voyage, and to judge from the reports of the mayor of Plymouth the townspeople were glad to see Hawkyns and his crews set off, for when on shore they were a troublesome lot. In 1544 Hawkyns, Elyot and Horsewell were given commissions to fit out four, six or eight barks at their own expense "to annoy the king's enemies and defend the realm," and two years later John Hawkyns, brother of William and appointed naval treasurer in 1578, was commanding officer of the Pauncey, a king's ship.

In 1531 Henry appointed two British consuls, one in the Island of Candia and the other in the City of Syo (?), as "master, protector, governor or consul of all merchants or other of the king's subjects," and these appear to have been the first English consuls appointed. It is almost needless to remark that Henry gave his admirals instructions to protect the merchantmen. Those to Dudley in 1537 state "You are to have a good eye to the succour of English merchants and if you meet any men-of-war, French or Imperial (*i.e.*, Spanish) whom you have reason to suspect of spoiling English subjects, as they of France have lately done, you shall first consider their power and do what you can to apprehend them without danger. If you meet with any merchantmen, French or Imperial, who under colour of traffic has robbed the king's sujects you shall see that he be punished as a pirate."

In another branch of engineering Henry VIII took an especial interest, and that was in the development of ordnance and its manufacture in this country. Guns having first been introduced and used on the Continent, it was to be expected that greater progress in design and construction should have resulted there than in England. Smaller types of guns had been made in this country before Henry's accession, but the larger had to be purchased from abroad.

In the first year of his reign, Henry VIII directed Spinelli, his ambassador in the Low Countries, to order from Hans Popenruyter, of Mecklin, then a centre of the gunfounding industry, 24 courtaulx or curtows and 24 serpentines, together with as many guns of 700 lb. weight as could be cast by a given date. Spinelli was also instructed to purchase, if possible, some guns which were being made at Mecklin for the King of Scotland. Twelve of the curtows were specified to be of 4,000 lb. weight, six being 7¾ ft. and six 7¼ ft. long. The other 12 were to weigh 3,000 lb. each, and the whole of the 24 to fire shots of 35 lb. weight. The serpentines were to weigh 1,100 lb. each and to fire shot of 4 lb. The tin used in the manufacture of the guns was to be supplied from England, as that obtainable on the Continent was dearer and of inferior grade. In February, 1610, Spinelli sent Henry pictures of the guns which he stated were supposed to be equal to the best in France or elsewhere. In the same month the king sent Spinelli the names which he desired cast on the guns and also devices for each of them. An advance of 500*l.* towards the cost was also made. Henry directed Spinelli to try and persuade Popenruyter to come to England to make the guns but he refused to come.

Popenruyter completed his contract in eighteen months. The weights of the guns as completed and the names inscribed on them are given in the State Papers. The total weight of the 48 guns amounted to 108,231 lb., the guns specified to be 4,000 lb. varying from 3,500 lb. to 3,941 lb., those of 3,000 lb. from 2,990 lb. to 3,224 lb., and the serpentines from 1,004 lb. to 1,168 lb. The curtows were named principally after the English counties and the serpentines after birds and reptiles real and fabulous.

The price paid for these guns was 6*l.* per cwt. Twelve of the curtows were probably mounted in the Great Harry, for she had 12 heavy guns, which, like those of the Regent are described as having "come out of Flaunders." Those of the Regent are stated to be "courtauds."

In passing it may be noticed that the calibres of the curtows and serpentines are respectively about 6 in. and 3 in., showing the early popularity of these sizes of guns. The name "Curtow" ceased to be used after about 1524, and the type was named a demi-cannon.

Twelve other guns, named the Twelve Apostles were supplied by Popenruyter in 1513 and were mounted in Calais. They fired shots of 20 lb., the charge of powder was of the same weight, and it is stated they could be fired 30 times a day. Simon Giles, another gunfounder of Mecklin, supplied Henry in the same year with a set of guns named the Twelve Sisters. After this the purchase of guns on the Continent practically ceased, for the king, seeing the disadvantage of being dependent for his supply on the Continent, and especially from Flanders, then a province of the King of Spain, the most powerful monarch of the time, encouraged the manufacture of guns in England by bringing over skilled workmen for making guns and instructing the native mechanics in the art. In 1543 a large number of small guns was ordered in Mecklin for the wars in Scotland and France, but these were constructed to a pattern gun made by Peter Bawde, the king's gunfounder.

(*To be continued.*)

* A bounty of 5*s.* a ton was also paid during the latter part of Elizabeth's reign. Between 1592 and 1595 2,683*l.* was paid on 48 merchant ships.

† Henry lent several of his warships to merchants for voyages to the Levant. Henry VII lent the Regent for a similar purpose and she had to be forcibly taken from the merchant to whom she was lent.

THE SULZER TWO-STROKE DIESEL ENGINE.

THE association of the firm of Messrs. Sulzer Brothers, of Winterthur, Switzerland, with the Diesel engine dates back to the year 1893 when they acquired the right to manufacture engines of this type under the patents of Dr. Diesel. The Diesel engine was then in its earliest infancy, for it was only in that year that the first experimental engine was constructed to Dr. Diesel's designs, an engine which could never be made to run and which finally exploded and nearly killed the inventor. The second engine of the type, in which for the first time compressed air was used for the injection of the fuel, was a very unsatisfactory machine and dangerous to operate, but Messrs. Sulzer were already convinced that the principle was sound and capable of development, so they set themselves seriously to study the conditions necessary for success.

Their first experimental engine, built in 1896, was the third Diesel engine in the world, so that the practical experience of the firm dates from a time well before the Diesel engine, even in the smallest sizes, was a commercial product and may be said to cover the whole period of its development. There is, moreover, probably no firm whose output of Diesel engines approaches that of Messrs. Sulzer Brothers, who have now constructed engines of this type aggregating over 1,000,000 h.p., this output representing the four-cycle and two-cycle designs approximately equally.

This record has been established since 1903, the year in which the production of Diesel engines on a commercial scale was commenced at Winterthur.

DETAILS OF 1350-B.H.P. TWO-CYCLE MARINE DIESEL ENGINE.

CONSTRUCTED BY MESSRS. SULZER BROTHERS, ENGINEERS, WINTERTHUR, SWITZERLAND.

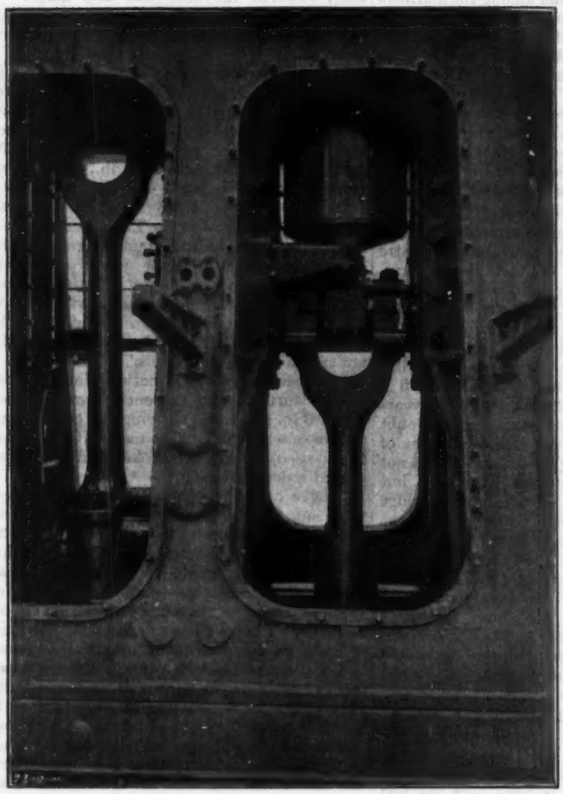


Fig. 5. Connecting-Rods and Piston-Cooling Arrangements.

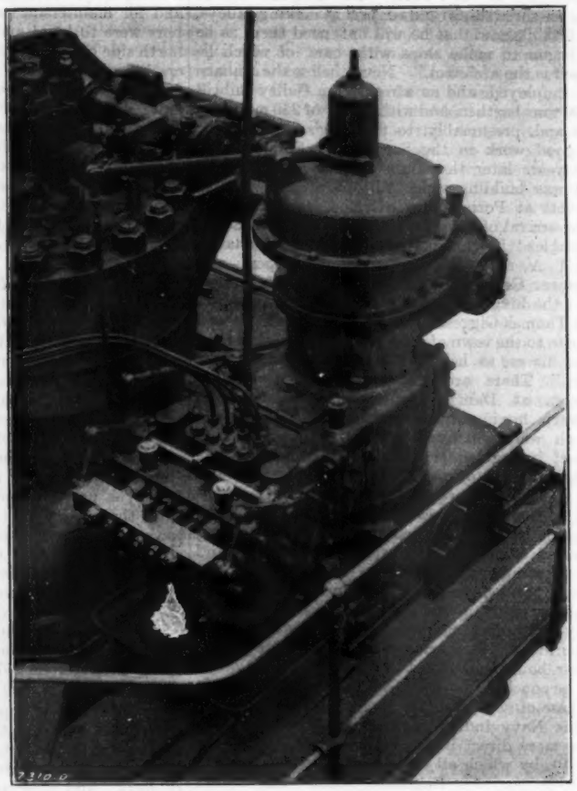
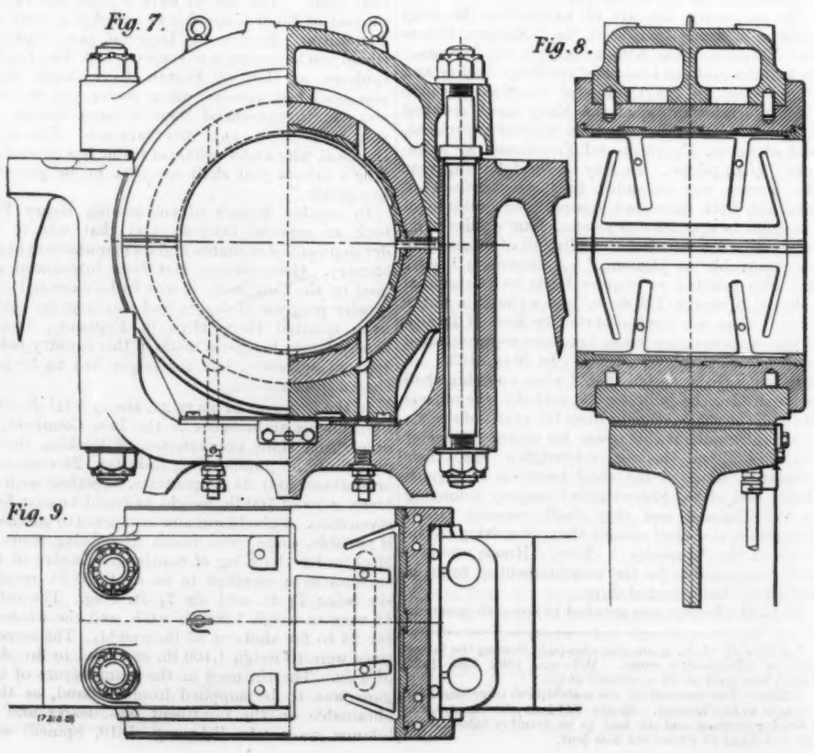


Fig. 6. Fuel Pump and Governor.

Another landmark in the history of the firm was the construction in 1905 of the first Sulzer reversible marine engine. Until this date the firm had confined themselves to the manufacture of engines operating on the ordinary four-stroke cycle, but the advantages of the two-stroke engine had been engaging their attention, and their first reversible marine engine embodied this principle. Such few marine Diesel engines as had been built previous to 1905 were irreversible, and drove the propeller by means of a dynamo and motor, the use of which was necessary to enable the direction of rotation of the propeller to be reversed. This method was adopted in the 1,100-ton oil tanker Vandale put into service in 1903 for the Caspian oil trade by Messrs. Nobel Frères, of Petrograd. The engine of Messrs. Sulzer, to which we have referred, was built in 1905 and exhibited at the Milan Exhibition of 1906, where it created a great amount of interest as being the earliest direct-reversing two-cycle marine Diesel engine ever constructed. It had four cylinders and was rated at 100 b.h.p. The success of this engine led to the construction of the firm's first two-cycle engine for land purposes, which was installed in the Aarau electric-power station in 1907. These early two-cycle engines were different in many respects from those built at Winterthur to-day. They had air-scavenging valves in the cylinder heads, a feature which complicated the casting besides involving other disadvantages, and a very important step in construction was made when Messrs. Sulzer abandoned these valves in 1909 and adopted port scavenging. This change permitted the cylinder heads to be castings of the greatest possible simplicity, and did away at one stroke with numerous potential sources of trouble.

It must not be thought that the development of the two-cycle engine by Messrs. Sulzer caused



DETAILS OF TWO-CYCLE MARINE DIESEL ENGINE.

CONSTRUCTED BY MESSRS. SULZER BROTHERS, ENGINEERS, WINTERTHUR, SWITZERLAND.

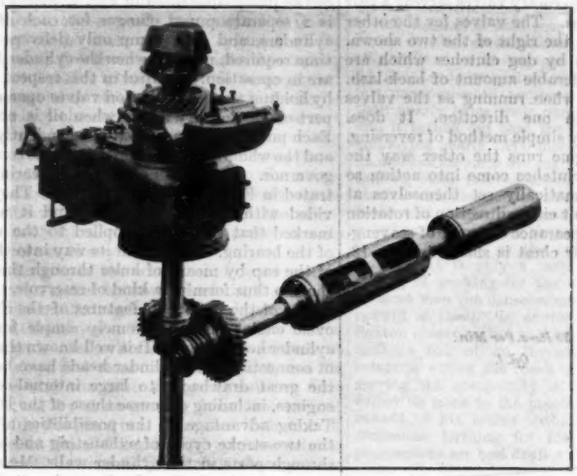


Fig. 10. Drive of Governor and Rotary Air Control Valves.

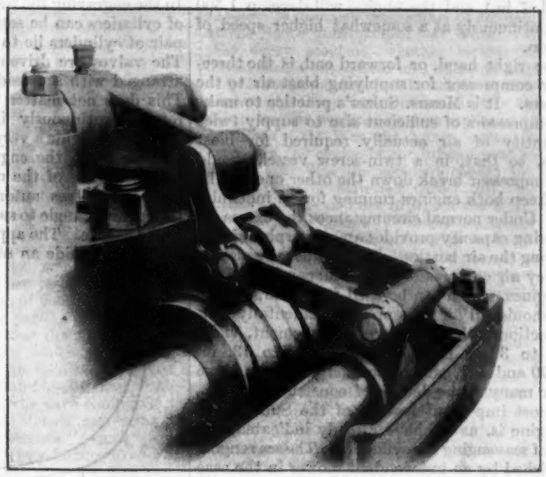
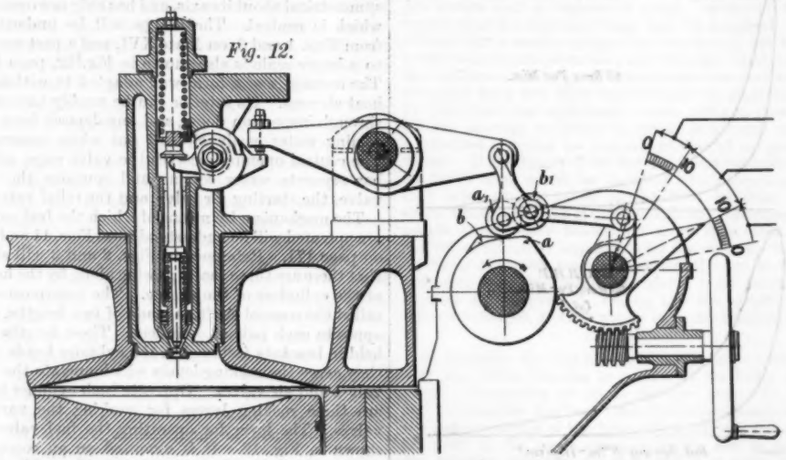


Fig. 11. Fuel Valve Control; Ahead Position.

Fig. 12.



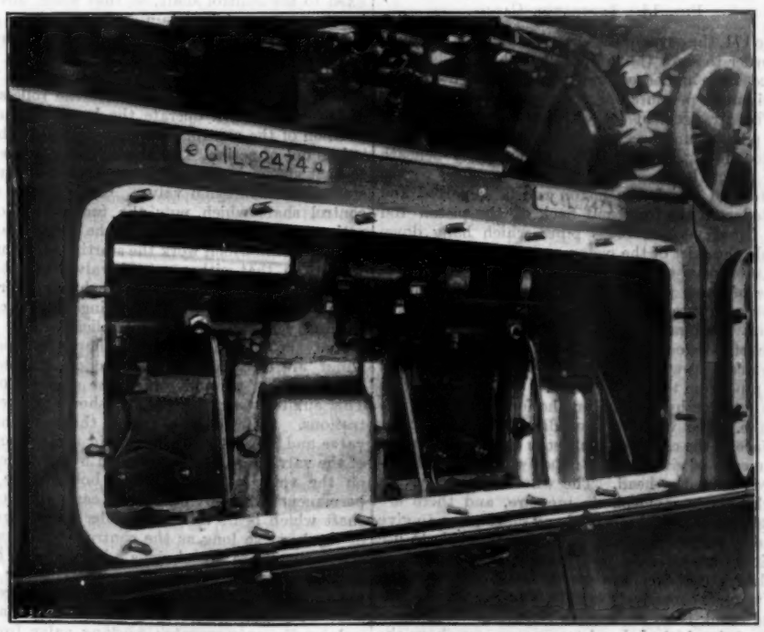


Fig. 13. Rotary Scavenging Air Control Valves in Position in the Air Chest.

any relaxation in their work in connection with four-cycle engines. They recognised that each type had its peculiar advantages and they constructed both with equal energy. They foresaw, however, that a demand would arise for marine oil engines of a larger size than were then called for, and they realised that the special features of the two-cycle engine would render it eminently suitable for marine work if its disadvantages, as then constructed, could be overcome. The relative position of the two types was dealt with by Dr. Diesel in his paper on "The Diesel Oil Engine" read before the Institution of Mechanical Engineers in 1912 and reproduced in our issue of March 22 of that year. After referring to the causes which led to the want of success of the early engines on the two-stroke cycle he said "Successful attempts to construct a two-stroke cycle Diesel engine on entirely new lines have, however, been made recently by Messrs. Sulzer Brothers, of Winterthur, so that to-day this type is on a nearly equal footing with the old four-stroke cycle engine. The four-stroke cycle engine still has a better combustion and a more economical fuel consumption, and is above all simpler in its method of working. It thus remains the standard perfect engine and still predominates for medium-sized stationary plants . . . but engineers are now doubtful whether this supremacy will last much longer. On the other hand, the two-stroke cycle engine, with its smaller cylinders, has now come into favour for stationary plants of higher horse-power and, as a marine engine, is likely to become the standard type."

The great improvement to which Dr. Diesel referred was the elimination of the scavenging valves in the cylinder heads, and the control of the scavenging air by means of valves in the air receiver outside the cylinder altogether. Another feature of the Sulzer two-cycle engine has always been the supply of scavenging air independently of the working cylinders, thus avoiding complications involved in the use of an annular extension of the working piston as an air compressor. Scavenging air was furnished in the earlier Sulzer engines by a blowing cylinder driven from the main crankshaft, and this method is still adopted in certain cases, but for the larger engines their general practice is to use an auxiliary rotary blower. In either case an ample volume of air is assured, so that the burnt gases are thoroughly swept out of the cylinders, and the metal of the walls and exhaust ports are washed with cool air immediately after every explosion stroke. It is indeed in the thoroughness of its scavenging, and in the methods by which this is attained that the Sulzer two-cycle engine is distinguished from others designed to operate on the same cycle.

Drawings of a large two-cycle marine engine, showing the general arrangement of its parts are

reproduced in Figs. 1 to 3, on Plate XVI, the external appearance being illustrated in Fig. 4. The engine develops normally 1,350 b.h.p. in its four cylinders when running at 95 r.p.m. The cylinders are 600 mm. (23·6 in.) in diameter with a stroke of 1,060 mm. (41·7 in.), and the engine will develop 1,500 b.h.p. continuously at a somewhat higher speed of revolution.

At the right hand, or forward end, is the three-stage air compressor for supplying blast air to the fuel valves. It is Messrs. Sulzer's practice to make these compressors of sufficient size to supply twice the quantity of air actually required for blast purposes, so that, in a twin-screw vessel, should either compressor break down the other one will be able to keep both engines running for an indefinite period. Under normal circumstances the excess air compressing capacity provides ample surplus air for re-charging the air bottles. There is usually also an emergency air compressor quite independent of the main engines, which can be used for recharging the bottles should all air pressure be accidentally lost. In connection with the general arrangement, views Figs. 1 to 3 on Plate XVI, Figs. 5 to 13, on pages 170 and 171, should be referred to, as these illustrate many of the details of construction.

The most important feature of the Sulzer two-cycle engine is, as we have already indicated, the method of scavenging the cylinders. The scavenging air, furnished by an independent blower in the case of engines of the larger sizes, is supplied at a pressure of about 1·5 to 1·8 lb. per square inch to the air receiver shown on the right-hand side of Fig. 3, partially under the platform. Inside the receiver is a cylindrical sleeve containing a rotary valve, the principal function of which is to keep the connection between the cylinder and the receiver closed until after the cylinder pressure has become reduced to that of the atmosphere. Without such a valve the exhaust gases would of course rush back into the receiver as soon as the piston commenced uncovering the scavenging ports on its downward stroke. The valve, however, being closed at this time, the gases are confined in the cylinder until the belt of exhaust ports are opened by the further motion of the piston. It should be remarked that there are two rows of scavenging ports, the upper row being controlled by the rotary valve, and the lower row being uncontrolled and communicating directly with the receiver. The piston on its descent passes first the controlled ports, but the rotary valve being shut, nothing happens. It next starts to uncover the exhaust ports on the other side of the cylinder. The burnt gases rush out and the cylinder pressure is reduced almost instantaneously to that of the atmosphere. This having been effected, the uncontrolled scavenging ports are next uncovered and a charge of scavenging air sweeps through the cylinder. Lastly, the rotary valve opens and admits scavenging air through the controlled ports simultaneously with the flow of fresh air through the uncontrolled ports, and the whole cylinder is effectively swept out by a very large volume of air. This air is directed upwards by the shape of the scavenging ports. It sweeps out the remainder of the burnt gases from the cylinder and has a beneficial cooling effect upon the cylinder walls and port-bars. The return of the piston first closes the uncontrolled row of scavenging ports, but scavenging is continued by the air coming through the upper row of controlled ports until the exhaust ports are closed by the piston. Air, however, still enters the cylinder through the controlled ports until these, in turn, are closed by the passage of the piston, and this extra air forced into the cylinder has the effect of filling the latter with fresh air at a pressure somewhat above that of the atmosphere. The rotary valve is not closed until the piston has passed the controlled ports, so that fresh air is admitted to the cylinder until the last moment. Thus "super-charging" is effected in a very simple manner, with the natural consequence of a compression temperature and pressure higher than would otherwise be obtained.

In the earlier designs of the Sulzer engine a double-beat drop-valve was used to control the scavenging air instead of a rotary valve, but the latter is now fitted to all engines. The sleeve in which the rotary valve works is bolted to the cylinder, and being right inside the air chest, air is admitted under the most favourable circumstances. Reference to Fig. 10, page 171, will make clear the method adopted for driving the rotary valves by means of skew-gear from the vertical governor spindle. They run at half the speed of the engine. In the engraving the two rotary valves serving a pair of cylinders can be seen. The valves for the other pair of cylinders lie to the right of the two shown. The valves are driven by dog clutches which are arranged with a considerable amount of back-lash. This does not matter when running as the valves rotate continuously in one direction. It does, however, provide a very simple method of reversing, because when the engine runs the other way the opposite faces of the clutches come into action so that the valves automatically set themselves at the required angle to suit either direction of rotation of the engine. The appearance of a pair of scavenging valves inside an air chest is shown in Fig. 13, page 171, the cover of the chest having been removed in order to show the interior. Each valve is lubricated from underneath in three places by means of oil under pressure.

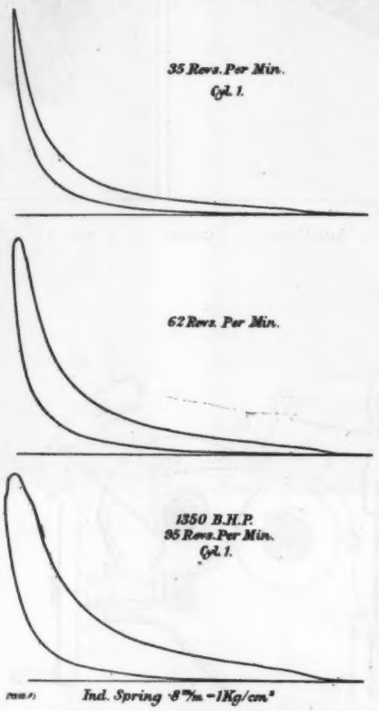


Fig. 14. Indicator Cards.

The arrangement for water cooling the head of the piston can be seen in Fig. 3, and it is also illustrated in Fig. 5, page 170. Immediately beneath the piston head is a cylindrical chamber, to the bottom of which the piston rod is spigotted and bolted. At the front and back of the piston rod are fitted vertical brass pipes which hang down inside the skirt of the piston and communicate with the interior of the chamber in the head. The lower ends of these pipes slide freely inside fixed sleeve pipes which are attached to hollow cast-iron brackets which communicate with a drain. One of the brackets also carries a small vertical jet pipe, which is concentric with the sleeve pipe, and over which the pipe from the piston slides. Water is forced up this jet pipe by a pump on the forward end of the engine. The water strikes directly on the inner surface of the crown of the piston and escapes freely by means of either of the pipes which hang downwards from the head. The whole cooling system works under atmospheric pressure, and there are no glands or swivel joints of any description to give trouble. These features make it practicable to use ordinary sea water for piston cooling, and this indeed is always used except in special cases, such as where the water is excessively muddy. In Fig. 5 the right-hand crank is on its bottom centre, and the lower part of the skirt of the piston is seen just above the cooling-water bracket. These piston skirts are very thin and light, as they transmit no power. They are steadied by means of clips which attach them to their respective rods at their lower ends.

The fuel oil is supplied to the cylinders by means of the pump illustrated in Fig. 6, page 170. There is a separate pump plunger for each of the four cylinders, and each pump only delivers oil at the time required, namely, when the cylinder-fuel valves are in operation. Control in this respect is effected by holding the pump-suction valves open during the part of the delivery stroke when oil is not wanted. Each pump can be adjusted independently by hand, and the whole arrangement is under the control of the governor. The design of the main bearings is illustrated in Figs. 7 to 9, on page 170. They are provided with forced lubrication, and it will be remarked that the oil is supplied to the under-side of the bearing. It can find its way into the interior of the cap by means of holes through the top step, the cap thus forming a kind of reservoir.

One of the noticeable features of the Sulzer two-cycle engine is the extremely simple form of the cylinder head design. It is well known that troubles in connection with cylinder heads have been one of the great drawbacks to large internal-combustion engines, including of course those of the Diesel type. Taking advantage of the possibilities afforded by the two-stroke cycle, of exhausting and scavenging through ports in the cylinder walls, Messrs. Sulzer have evolved a design of cylinder head which could hardly be surpassed for simplicity. It is perfectly symmetrical about its axis, and has only one opening, which is central. The design will be understood from Figs. 1 and 3, on Plate XVI, and a part section to a larger scale is also shown in Fig. 12, page 171. The casting is of a form well adapted to withstand heat stresses. Its interior can be readily examined through inspection doors, and any deposit from the cooling water easily cleaned out when necessary. The central opening receives the valve cage, which has separate water cooling and contains the fuel valve, the starting air valve, and the relief valve.

The mechanism by means of which the fuel valves are operated will be understood from Figs. 11 and 12, on page 171. Reference to Figs. 2 and 3 will show that there are three shafts passing along by the heads of the cylinders of the engine. The innermost one, called the control shaft, is made of two lengths, one opposite each pair of cylinders. These lengths are held in brackets fastened to the cylinder heads, and they carry the rocking levers which operate the fuel valves and air valves. Opposite each cylinder head are three rocking levers for working the various valves. The lever for operating the fuel valves is shown in Fig. 12. It is mounted on an eccentric fixed to the control shaft, so that when this shaft is rotated through a certain angle, the centre of the lever is raised. As the working end of the lever is held downwards by a light spring, not shown in the illustration, the effect of raising the centre is to lift the other end sufficiently to raise the rollers clear of the cams which operate the lever, so that the rotation of the control shaft therefore puts the fuel valves out of action. An arrangement very similar to that shown in Fig. 12 is used for operating the starting air admission valves. The rotation of the control shaft which puts the fuel valves out of action simultaneously lowers the centres of the rocking levers which work the starting air admission valves, so that either set of valves can be put into operation at will, and the change over from running on starting air to running on fuel can be effected with the greatest simplicity. The opening of the starting-air valve, however, does not admit air directly to the cylinder, for there is another valve through which the air has to pass. This auxiliary air valve is not shown in the illustrations. It lies close alongside the fuel admission valve and its seating is formed in the bottom face of the valve cage. It is operated by a lever carried on the valve cage, this lever holding the valve permanently open by means of a cam on the control shaft which bears against a roller on the free end of the lever so long as the control shaft is set for starting. There are obvious advantages in having two starting air valves in series. The one which opens directly into the combustion chamber remains shut while the engine is working on fuel and so isolates the cam-operated working valve from the

burning gases. The latter valve is thus protected from troubles due to the deposit of carbon or tarry matter, and if need be it can be removed and examined when the engine is running. The space between the two valves is not under pressure when the engine is working, as it is in communication with the atmosphere, consequently it is impossible either for starting air to leak into the cylinder or for burning gases to find their way back into the starting air system. Another advantage of the arrangement is that the opening of the air valve, which admits air directly into the combustion chamber, acts as a compression release when the engine is starting, since the air which would otherwise be compressed in the cylinder can pass freely away to the atmosphere. As soon as the cam-operated air valve opens to admit the starting air, the escape to the atmosphere is automatically closed, and the starting air passes directly to the cylinder.

The two lengths of the control shaft are operated independently, either by handwheels in the smaller engines, or by small air cylinders in the larger engines of the type illustrated. The camshaft, which runs close alongside the cylinder heads, as shown in Fig. 12, has two fuel cams for each cylinder, one for going ahead and the other for going astern. The shaft is driven by skew-gearing from the vertical shaft carrying the governor. The cam marked a in Fig. 12 works the rocking lever by means of the roller a_1 when the engine is running ahead, while, when it is going astern, the lever is operated by the cam b and the roller b_1. Either of the cams can be brought into action at will by means of the handwheel and worm-gear shown, which causes the reversing shaft to be rotated through a sufficient angle. When the reversing shaft is in mid-position neither cam is operative, as both rollers are clear.

To start the engine from cold all that has to be done is to put the reversing shaft in the position corresponding to the direction in which the engine is required to run, and to put the control shafts in the position for operating the air valves. If the starting air is then turned on, the engine will commence to rotate, as there is no dead centre in a two-cycle four-cylinder engine, and one cylinder will therefore be in a position for starting. As soon as the engine is moving round, one of the control shafts is moved into the running position. This has the effect of closing the starting air valve, putting the cam-operated air valve out of action and bringing the cam-operated fuel valve into play on each of the two cylinders which the control shaft serves. As soon as these cylinders are firing, the other pair are similarly changed over from air to fuel, and the whole engine is then in its normal working condition.

The speed of the engine is controlled by varying the quantity of fuel oil admitted to the cylinders, this being effected by regulating the delivery of the fuel pump. The engine is extremely handy, both as regards speed control and reversing, and during some very thorough tests of one of these large engines which we witnessed recently at Messrs. Sulzers' works, absolute smokelessness was maintained under all conditions of power and speed, whether running on gas oil, tar oil or Mexican fuel oil, the change from one fuel to another being made by merely turning a cock. Numerous indicator cards were taken on the occasion referred to, three of these, which are typical of the bulk, being reproduced in Fig. 14, page 172. They were selected to show the effect on the diagram of running at different speeds, and were all taken from the same cylinder, although it may be mentioned that the cards from the different cylinders were indistinguishable. In the case of the uppermost card the engine was running at 35 r.p.m.; in the next the speed was 62 r.p.m.; while in the last the full power of 1350 b.h.p. was being developed at 95 r.p.m. During these trials the engine was running on a dynamometer brake. The diagrams are reproduced to exactly half their original linear dimensions. The extremely sharp "toe" in each case will be noted. The somewhat abrupt drop of pressure just before the toe is due to the piston passing the scavenging ports, and thus permitting the gases to expand into the space between these ports and the rotary valve, which is, of course, closed at this time.

(To be continued.)

INDUSTRIAL NOTES.

IN an interesting contribution to *Current Opinion*, Mr. James Sexton, M.P., sets forth once again the view that better work would be obtained had the worker a real sense that he was working for the good of the State. Unfortunately, all the available evidence tends to the conclusion that men employed directly by the State or the municipalities, work, if anything, less efficiently than if engaged by a private employer. At the Leeds municipal strike it was found that a few unexperienced amateurs got through more work than nearly twice their number of the regular hands, and it turned out that the various departments were employing nearly 1,000 more men than was necessary. In another instance the engineer in charge of some road making being carried out by "direct labour" remonstrated with his men upon the smallness of their output, to be told "that they never had worked as hard for a public authority as they did for a contractor, and never meant to, as the contractor had to make a profit." It is only a very few men, to whom the feeling of working for the State is an incentive, but to most men the consciousness of good work done is a reward in itself. In another part of his article, Mr. Sexton observes that to "say that the man who makes millions out of an invention which brings added comforts within the reach of his fellow-countrymen is serving the community is undoubtedly true, but it would be more to the point if he gave the public the benefit of his brains without himself extracting the uttermost farthing for his services." Such general propositions are best dealt with by reference to concrete cases. Sir Henry Bessemer made some 800,000*l.* out of his inventions, which, however, were estimated by an American economist as worth to the world 100,000,000*l.* per annum over a number of years. It would thus appear that the relatively large sum he acquired constituted but a wholly insignificant fraction of the total benefit which accrued to the public at large. Moreover, the millions made by great industrialists are commonly ploughed back into their business and are represented by the plant and equipment which make it possible for the average workman to attain in normal times a standard of living far superior to that of his grandfather. If Mr. Henry Ford had not made his millions, far fewer men would be enjoying the exceptionally high rates of pay ruling in the Ford factories. In short, where a fortune is made in industry, the common people of necessity benefit far more than does the individual primarily responsible for the success. Great creations of wealth seem always directly due to some autocrat, who, to pursue his plans, must have the "power of the purse." Failing this the wealth will fail to be created, and the public be so much the poorer.

AT Croydon the Chamber of Commerce co-operates with the public libraries in order that the latter may supply information of use to business men. To this end a committee has been formed of representatives of the various trades of the town which advises the chief librarian on the needs of these trades, and to which the librarian may turn for the solution of many questions which are asked him. In the Croydon Reference Library are a very complete set of town and trade directories, year books, time-tables, codes and maps, in addition to ordinary books on business; but the special feature of the work is the vertical file of clippings, articles, pamphlets, &c., on current business and public questions, which has been compiled and is maintained, with the co-operation of the business committee. The telephone is within hand's-reach of the books, magazines and files, and business men are invited to make inquiries by telephone. They made 1,200 last year.

In an interesting note on accident prevention contributed to *Industrial Welfare*, Mr. D. D. Goldingham, the managing director of the National Employers' Mutual General Insurance Association, Limited, points out that the vast majority of industrial accidents do not occur in connection with machinery at all, and that whilst it is very important that machinery should be efficiently guarded, the manufacturer must not consider his duty in the matter accomplished when this has been done. Accidents due to machinery are relatively very serious in type, but three-fourths of the accidents recorded are classed by the factory inspectors as non-mechanical. This conclusion is borne out by the experience of the Mutual General Insurance Company, who find that 90 per cent. of the accidents which occur are not due to lack of guards, but to other causes.

An interesting diagram has been prepared by Messrs. Beyer, Peacock and Co., Limited, which shows in a most striking manner the allocation of the gross profits of the business for the year 1921. Wages amounted to 453,600*l.*, working expenses to 116,000*l.*, salaries (foremen, staff and directors) aggregated 40,000*l.*, Workman's insurance cost 10,400*l.*, whilst 65,000*l.* was set aside for contingencies. The dividends absorbed 44,000*l.*, or less than one-tenth of the takings of the wage earners.

An interesting account is given in *Industrial Welfare* of the steps taken some thirty years ago, by Sir George Livesey, to diminish the number of accidents occurring at the South Metropolitan Gas Works. He arranged that every accident, whether serious or relatively trivial should be inquired into by a jury of 12 workmen, of which a proportion had to belong to the department concerned. They were instructed after obtaining and discussing the evidence to give replies to the following questions: (1) Was the injury caused by accident arising in the course of the injured member's employment? (2) Was the accident caused by any defect in the plant or materials used? (3) Was there any mistake in the manner in which the work was done? (4) Was the accident due to the negligence or want of care or foresight of any officer or foreman? (5) Was the accident caused wholly or in part by any carelessness or negligence of the injured person or by that of any fellow worker? (6) Was the accident attributable to the serious and wilful misconduct of the injured member, or any other person? (7) Was it a pure accident, for which no one was to blame? (8) Can anything be done to prevent a similar accident? The last question opened the way for a variety of accident-prevention suggestions, many of which have been adopted.

Iron ore miners' wages in Cumberland are reduced slightly as the result of the new ascertainment price of hematite pig-iron, mixed numbers, which is reduced to 98*s.* 8*d.* per ton, compared with the last previous ascertainment price of 101*s.* 5*d.* per ton. The wages scale per shift until the first bargain letting day in September is as follows, the reductions having averaged from ¼*d.* to 2*d.* per shift: Underground workers—miners working bargains, 9*s.* 11*d.*; miners' minimum, 7*s.* 3*d.*; underground first-class or leading labourers, 6*s.* 4*d.*; trailers, payment according to their respective categories. All other underground workers' wages are reduced 1*d.* per shift, except those of boys, which are reduced by ½*d.* per shift. Surface workers—winding enginemen, 8*s.* 8*d.*; joiners, 9*s.* 1*d.*, plus 6*d.* per day tools allowance; chargemen, mineral shot borers, 9*s.* 1*d.*, plus 3*d.* per foot; blacksmiths, 9*s.* 1*d.* Other surface workers' wages, with the exception of boys, are reduced by 1*d.* per shift, the reduction of boys' wages being ½*d.* per shift.

The Operative Spinners' Association at Oldham are endeavouring to establish a rule that, whatever his natural ability, no "piecer" shall be promoted to the position of spinner until he is 21 years old. The Employers' Association object to this restriction, stating that they are "definitely of the opinion that it is inadvisable to agree to any arbitrary limit of age." They consider that the true standard for promotion is efficiency. By this standard alone will encouragement be given to youthful aspirants to fit themselves for the positions they have in view. "It may," they say, "be taken that in general practice every manager looks to the interest of the firm he represents in making a selection of piecers for promotion, and the question of age will be more or less regulated according to the supply of labour available."

Very large orders are reaching the home makers of textile machinery to equip new cotton mills to be laid down in China by Japanese capitalists. Platt and Co., Limited, of Oldham, are to supply over 1,000,000 spindles, and other makers have received orders for lesser numbers.

The Grantham Board of Guardians, in conjunction with the Town Council, have arranged to provide work for the unemployed men in receipt of out-relief. The council will find the work, and the Guardians will pay for it, the unemployed thus being given an opportunity of earning the amounts they would otherwise get in relief. In abstract theory this course has much to recommend it, but some past experiences have been extraordinarily disappointing, the work done having in some cases cost about three times as much as if carried out by contract in the usual way.

The following official statement has been issued by the Mining Association: The subject of coal prices has recently been receiving considerable attention in the press, particularly with reference to the increase of 2*s.* per ton retail price of household coal in London. The result of the ascertainment of the proceeds and costs of the working of the coal-mining industry for June for the purpose of determination of wages in August, which is now to hand, is of interest in this connection. There was a gross trading loss of about 550,000*l.* in June for the whole of the coal-mining

industry throughout the country, equivalent to about 9*d.* per ton of coal. In the eastern federated area (Yorkshire and the Midlands), from which London derives its supplies of house coal, there was a trading loss during the month of over 330,000*l.*, or about 1*s.* 5½*d.* per ton. The average earnings per shift worked in June, taking into account all persons in the industry—men, women and boys—were 9*s.* 8½*d.*, or about 50 per cent. more than the 1914 figure of 6*s.* 5½*d.*

A settlement of the dispute with respect to dockers' wages was reached in London last Saturday, and the threatened strike at the ports throughout the country is averted. For over 3 hours a delegate conference of the National Transport Workers' Federation discussed the final terms obtained by the Negotiating Committee, namely, a reduction of 2*s.* per day, bringing the wage down to 10*s.* per day. Mr. Harry Gosling, Mr. Ben Tillett, M.P., Mr. Ernest Bevin, and other leaders had to fight hard for the acceptance of the terms they had negotiated, but eventually they were agreed to by a considerable majority. It is unofficially stated that some concessions have been made, that the 2*s.* reduction has been divided and spread over several months; and that something has been gained in regard to stabilisation of wages for a period.

It would appear from an article published last Wednesday in the *Manchester Guardian* that until the war, labour troubles in America were characterised by an entire absence of violence. At any rate, the ingenuous and doubtless well-meaning New York correspondent of that paper attributes the outbreaks which have disgraced the present disputes entirely to the fact that during the war "conscientious objectors" and their kin received scant consideration in the United States. The theory is no doubt an attractive one to a certain type of mind, but as is somewhat characteristic of many theories favoured by this class of individual, it accords extremely badly with the actual facts. It has indeed been a commonplace for years that labour disputes in America have been in general far more violent than in this country, from the time of the "Molly Maguires" to that of the union leaders in the structural steel trade, who arranged for the blowing up with dynamite of buildings erected by non-union labour. When these miscreants were at last arrested, certain publicists in this country strenuously maintained up to the very moment at which the evidence of guilt became conclusive, that the outrages in question had been got up by the "capitalists" in order to throw discredit on the union. Here, again, the writers were swayed by *a priori* predispositions in place of by the historical fact, that outrages of a similar kind in the past had always been proved to be due to labour extremists and never to the employers.

There seems to be no immediate prospect of a settlement of the railroad and coal-mining disputes in America, as the railroads have refused to restore to their seniority rights, the men who left the public in the lurch. The question here involved is no doubt a very difficult one. Railroad employees have frequently special privileges which are granted largely because of the importance of the transport service to the community at large, and if the attempt be made to force or maintain unreasonable concessions, by methods which do not differ in principle from those employed in such operations as cornering wheat, it does not seem unfair that failure should involve some penalty. As matters stand there appears to be a possibility that the strike may spread to other unions not yet involved. The men are said to be hopeful that the railways will be unable to continue, owing to the difficulty of maintaining the rolling stock in repair, but past experience gives little warrant for believing, that in the absence of *sabotage*, there will be any serious difficulty in maintaining the really essential services. Ultimately the dispute will probably be settled by the pressure of public opinion, which, however, is seldom well-informed on matters of this kind, a fact which emphasises the advantages of industrial courts of inquiry in which the actual facts of a case can be established.

NOTES ON NEW BOOKS.

Warm water has long since become so indispensable for various purposes in the household and in parts of works where steam is not employed as a source of power, for heating, cooking, cleaning and other services, that the production and supply of warm water well deserves a treatise of its own. The *Warmwasserbereitungs- und Versorgungsanlagen*, of Wilhelm Heepke (München und Berlin, 1921: R. Oldenbourg, price 120 marks), forms the fifth volume of the Technische Handbibliothek, and is written by an expert sanitary engineer for the engineer, architect and student. The 411 illustrations of the octavo volume of 706 pages—diagrams of tanks, furnaces, preheaters, economisers, radiators, supply systems, valves, control apparatus, meters and indicators—testify to the practical character and value of the book, which is now in its second enlarged edition, the first edition having been published in 1909. The infrequent cost estimates are generally marked b.d.K., which means, before the war. Most of the machinery and apparatus noticed are of German origin. One branch of the problem, the deaeration of the water, so desirable for the prevention of corrosion with all its unpleasant consequences, has not received that attention in Germany which America in particular, who has been far less troubled during recent years, has been able to pay to it. The last sections of the volume exemplify the calculations of heating systems and their parts, radiators, pipes, tanks and accessories.

That coal-tar colours lend themselves to the decoration of textiles, wood, leather, horn, hairs and furs is well known, and it is understood that success depends upon attention to details. Mr. A. Clarke, F.C.S., late of Messrs. Levinstein and other firms, devotes a demy octavo volume (London: Constable and Co., Limited, 10, Orange-street, W.C. 2; price 6*s.*) on "*Coal-Tar Colours in the Decorative Industries*" to the subject. The pages are small and the type is not, so that it would not take very long to peruse the 165 pages if the book were a novel. The main divisions deal with lakes and pigments, with the staining and dyeing of wood, paper, leather, fur, oils and spirits, and with miscellaneous applications of coal-tar colours; short bibliographies are given. The dyeing, as distinct from staining, of wood in the grain is receiving much attention at present.

Although the average pocket book will perhaps go into the average pocket it will not stay there with any great comfort to the wearer of the garment containing the pocket, so that those whose sphere of work it deals with should have a welcome for the "*Electrical Installation Rules and Tables for Rapid Reference*," compiled by Mr. W. S. Ibbetson. This publication may actually be carried in the pocket by a wireman, contractor, or anyone else concerned, as it measures only 2¾ in. by 2 in., and is ¼ in. thick. The book differs from most pocket books not only in dimensions, but in the fact that the information it gives is concerned entirely with a comparatively small branch of electrical engineering. This enables it to be kept within its very moderate bulk, although assistance in this direction is afforded by the concise arrangement and the absence of padding. As an example of the type of information given the last item in the book may be quoted. This refers to water heating by electricity and states "to raise 1 gallon of water to boiling-point requires, theoretically, half a unit of electricity. Allowing for radiation, estimate the boiling of 12 pints of water per Board of Trade unit when calculating the cost of operation of kettles and small boilers." This might be criticised from the point of view that the initial temperature of the water is not stated, but it is exactly the type of information that the ordinary wiring contractor wants. There are very many tables in the book—sizes of wire that wood casing will carry; sizes of wire required for a given number of lamps; intensity of illumination recommended for various classes of service, and so on. The book should be of much value to a large class of workers. It is published by Messrs. E. and F. N. Spon, Limited, at 1*s.* 6*d.* net.

The Geophone.—The Geophone, which was introduced during the war for the purpose of detecting enemy countermining, has been further developed and is now of practical value, according to the United States Bureau of Mines, in detecting various kinds of underground sounds. The instrument is considered to be so serviceable that one is included in the equipment of the Bureau's mine-rescue cars. In tests which have been conducted it appears that this instrument has rendered audible the blows of a sledge on a working face 650 ft. distant though various rooms and entries intervened. Talking and singing could be detected through 150 ft. of solid coal. The instrument is essentially a small seismograph, and consists of a lead weight suspended between two elastic diaphragms cutting across a small air-tight box. If the instrument be placed on the ground and the latter is struck the concussion shakes the case and the instrument transforms the earth tremor into an audible sound wave. The Bureau has experimented with different kinds of diaphragms, metal having been found more satisfactory for these than mica. Various metals were tried, the maximum allowable thickness for most of these being ·025 in., though with "Non Gran" bearing metal a thickness of ·035 in. was satisfactory. It is considered from experiments that the Geophone can be used with advantage for the location of mine fires which are always accompanied by a certain amount of noise underground. They can also be employed to locate the position of a ventilating bore hole which has drifted from the vertical, and failed to strike into the workings where expected. Both direction and elevation can be checked by this means. The United States Bureau of Mines has recently issued a technical paper (No. 277) on the subject, going into the subject in considerable detail.

INSTRUMENTS FOR USE ON AIRCRAFT.

The new aircraft instruments which we illustrate in Figs. 1 to 9, on this and the opposite page, were exhibited by Major C. J. Stewart and Mr. E. A. Griffiths, of the Instrument Research Section of the Air Ministry, on behalf of that department, at the June Soirée of the Royal Society.

The idea of the first instrument, the Altimeter Dial, Fig. 1, is due to Professor Filon, F.R.S. It is an aneroid barometer provided with a scale which may be adjusted to suit any variations in pressure and temperature. The atmospheric temperature is known to fall, as the height above the earth's surface increases, at a rate of about 1·9 deg. C. per 1,000 ft. This temperature gradient has roughly the same slope all the year round, but it is displaced parallel to itself by changes in the ground temperature. A temperature-height relation calculated for average temperature values will be considerably in error during the hot and the cold seasons, since the change of pressure from ground level up to any height is proportional to the average density of the air column in question.

Professor Filon's expansible scale can be adjusted to fit the particular atmospheric conditions of the day. The scale is a flexible metal strip, having attached to it pegs carrying white figures which mark the graduations. The divisions represent heights of 1,000 ft., and the figures 25 and 26, for example, thus mean 25,000 ft. and 26,000 ft. As shown in Fig. 1, the strip is coiled into a spiral groove of the dial plate.

Fig. 1.

The strip is anchored at the one end, and clamped by means of the milled head seen on the left of the instrument. The dial itself can be turned by the aid of the milled head seen on the right hand side of the instrument. When this is done, the stationary strip changes its position with respect to the dial; when the strip, or a section of it, lies in one of the external convolutions of the spiral, the angle subtended by a certain number of graduations will be smaller than when the coiled strip has been brought nearer to the centre of the dial. Thus the scale can be extended or contracted in a predetermined manner depending upon the radius of the portion of the groove in which it is coiled. The pitch of the spiral has been calculated to fit the data on temperature gradients.

The temperature scale in degrees Centigrade is engraved on the dial; these latter figures near the edge of the strip appear faint in our illustration because they are marked in red. When an observation is to be taken, the knob on the left of the case is loosened, and the strip is pulled or pushed a little so that the zero height mark, seen in the figure to the left of the pointer, comes under the pointer. A temperature reading is then taken on the ground in the shade, and the dial is turned until either the letter S (standing for summer observations) or the letter W (winter) is over that temperature division. A small readjustment of the height zero of the spiral may finally be required. Actual flying tests have shown that the instrument is capable of indicating the true height at any given time within about 2 per cent., provided the altitude be above 2,000 ft. In the lower strata of the atmosphere air currents are too irregular and temperature inversions too frequent to make the readings reliable.

The two other instruments we notice are more for aeroplane testing than for regular service, and though they are of comparatively light weight, small weight is not a primary condition of such devices. The Air-Speed Recorder, shown in the illustration, Fig. 2, has been developed by Messrs. Munro, of Tottenham, in conjunction with the Instrument Section of the

Air Ministry. This instrument records speeds up to 80 m.p.h. The ordinary air-speed indicator, upon which the pilot relies, measures the pressure head produced in a Pitot tube mounted on a strut of the machine. These indicators have been standardised because they permit of absolute interchangeability, the head being proportional to $\frac{1}{2}\rho v^2$, where ρ is the density and v the velocity of the air. It was desirable that the air-speed recorders should have the same characteristics as the standard indicators, since in that case the recorder could be joined to a branch pipe from the indicator.

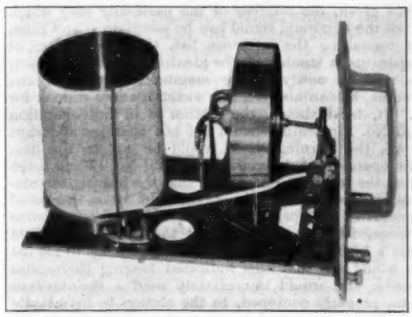


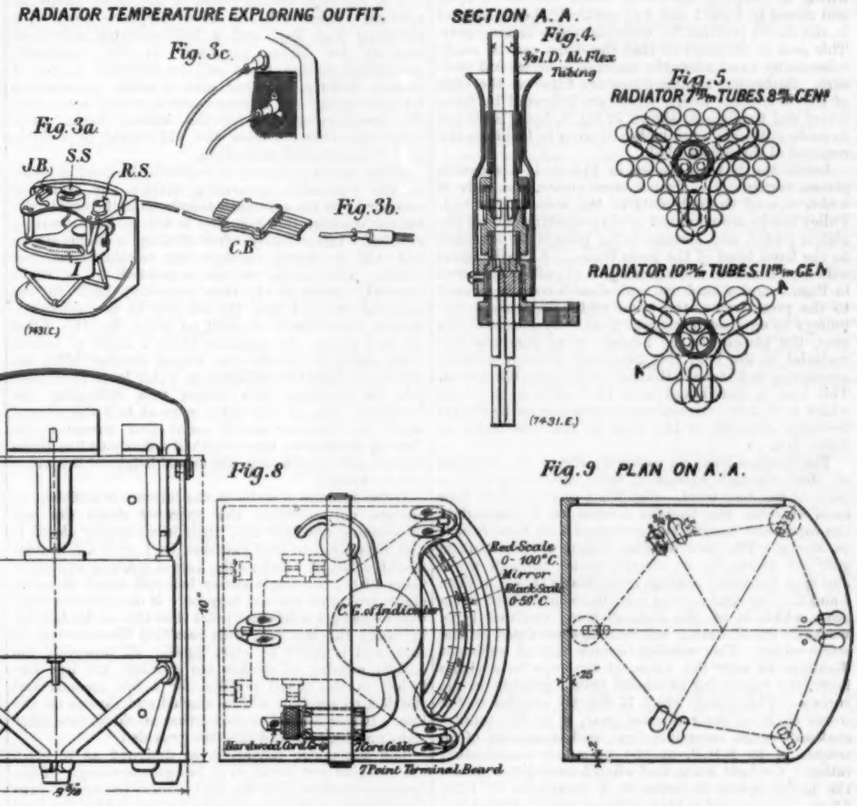
FIG. 2.

The construction of a speed recorder is, however, a matter of considerable difficulty, because the pressures available are low and the vibrations are troublesome. Most of the early instruments used by the department were of French manufacture.

In the Munro instrument, as in most instruments of this type, the measurement of the air velocity depends upon the determination of a dynamic pressure difference produced in tubes mounted on the machine. There are either two tubes, the dynamic pressure tube and the static pressure tube, mounted close to one another, and both pointing forward; or the arrangement of the two tubes is concentric. The dynamic pressure tube, the Pitot tube proper, faces the air current with its open mouth; the other end of the tube is connected to one side of a pressure gauge. The static pressure tube is closed by a cone in front and connected with the other side of the gauge at its far end; the circumference of the cylindrical portion of the tube is perforated by several rings of small holes, sufficiently large to ensure that the air pressure inside this tube always adjusts itself to the pressure of the atmosphere outside, no matter at what speed the tube is moving with the machine. That this pressure balance is maintained was established at the National Physical Laboratory by experiments made with the whirling table. When the diameter of the Pitot tube is about 0·3 in., the holes in the static tube would have a diameter of 0·03 in. In the concentric arrangement the Pitot tube is the inner tube and the holes are so made that the annulus of the outer tube communicates with the atmosphere. Fig. 2*b* is a diagram of this concentric pressure tube.

In the illustration, Fig. 2, the ends of the two tubes are joined to the nipples seen on the right-hand side of the frame, from which copper tubes extend over to the cylindrical brass box which they enter at the back. In this brass box lies a capsule made of corrugated sheet silver; the interior of this capsule communicates with the Pitot tube, whilst the static pressure tube ends in the interior of the box in which atmospheric pressure is thus maintained (diagram Fig. 2*a*). Motion is communicated from the capsule by a rod, passing through the side of the box in a ground-in fit, to a lever mechanism. The short rod is horizontal, and between it and the upper end of the counterweighted lever is interposed a very closely-wound spiral spring, to allow of sufficient flexibility without back lash; the rod and spring are in line and can hardly be distinguished from one another in our figure. To the shaft about which the lever turns is attached the long pen arm which stretches over to the drum. The drum is clock-driven and generally makes one revolution about its vertical axis in 40 minutes; it can be started from outside the case. The cam device, which will be seen at the bottom of the drum, lifts the pen over the clip when it comes round, rotating with the drum; the pen is shifted with the aid of a screw on the right-hand side. The instrument is very compact and fits into a case less than 10 in. long; it weighs 5 lb. complete. The small dimensions are important when several recorders have to be carried in the restricted space of the cockpit of an aeroplane. The instrument is calibrated against a water column; at the maximum speed of 80 m.p.h., for which this particular instrument is designed, the pressure head would amount to 3·2 in. of water. In order to avoid complications correcting devices have not been added to this speed recorder; corrections are made subsequently from the known temperature and altitude of the machine.

The third instrument, the outfit for exploring radiator temperatures, is somewhat more bulky and heavy. The instrument was designed for the purpose of determining the temperature distribution at different points of the radiator of an aero-engine and its connecting pipes. With the increasing tendency towards high-power aircraft the necessity of obtaining the utmost efficiency of the radiators has assumed greater importance; while on the other hand it is essential to keep the radiator dimensions within reasonable limits and to maintain an efficient circulation, since dead water spaces detract considerably from the cooling power. The instrument may be described as a multiple thermo-electric thermometer; Fig. 3*a* explains the general arrangement, Figs. 4 and 5 illustrate the thermo-couple plugs and sockets, and Figs. 6 to 9 show the mode of suspension of the instrument adopted to eliminate disturbance of the galvanometer by the vibrations of the machine. A six-junction thermo-couple is arranged in a form suitable for insertion in the tubes of the radiator and also in standard pockets in the water pipes. Each set of junctions measures the temperature at the point to be dealt with as referred to the atmospheric temperature, this point being connected to a moving-coil galvanometer, through a selector switch S.S. This switch, totally enclosed, is mounted on the top of the indicator case I, which further supports the junction-box J.B. for the cables and the range switch R.S. The selector switch and connector-box C.B. are joined by flexible aluminium tubing which is continued to the plugs. Each set of junctions is enclosed



The galvanometer (Figs. 3*a* and 8) is a direct-reading instrument provided with two scale ranges, the one in black for temperatures from 0 deg. up to 50 deg. C., the other in red for 0 deg. to 100 deg., either of which is put into circuit by the two-way change-over or range switch R.S. mentioned. The suspension of this indicator in the strong case is effected by means of $\frac{1}{8}$ in. ropes of solid rubber and of soft and hard rubber buffers and feet as shown in Figs. 6 and 7; the rope has three loops on the top, and the indicator is secured below by one continuous rope passing through three eyes at the bottom. The positions of the eyes on the under side of the indicator and of the holes in the base-plate will be understood from Fig. 9; the brass handle for carrying the instrument is shown in Figs. 6 and 7, in a three-prong fitting designed to enter the honeycomb tube of any pattern radiator now in use or a standard thermometer pocket. Each prong contains two junctions, and the six junctions of a set are coupled in series to increase the thermo-electric force to be measured. The prongs are tubes $\frac{5}{32}$ in. in diameter. Fig. 4 shows a thermocouple plug with its flexible tubing, $\frac{1}{4}$ in. internal diameter, its rubber washers at the lower ends and the bolts to suit the radiator; the radiator tubes may be 7 mm. or 10 mm. in internal diameter, and flanged nuts (shown in Figs. 3*c* and 5) fit the plugs to facilitate the insertion.

ELECTRICALLY OPERATED BALING PRESS.

In order to avoid the necessity for a preliminary treading down of the material in baling such fibrous substances as raw cotton or greasy or scoured wool, it is necessary to employ a press having a box of large capacity and a platen with a long stroke. Particular attention has been given to these features in the electrically-operated baling press illustrated by the engravings on page 178, which has been designed and constructed by Messrs. Hindle, Son and Co., of Union Engineering Works, Haslingden, Lancashire.

In this press, the box, which is of the fixed vertical type, is constructed of steel plates and sections, and measures 4 ft. by 2 ft. by 12 ft. 6 in. deep, so that its capacity is 100 cubic feet. More than half of the box, as shown in Figs. 3 and 4, is situated below the ground level, and the upper end is mounted on rollers so that it can easily be removed to facilitate the filling of the box from the floor above; the material can, also, be filled into the box by sweeping it along the floor and through a door in the side. At the front and rear of the upper portion of the box, hinged doors are provided to give access to the compressed bale for wiring or hooping, the doors, which are shown open and closed in Figs. 1 and 2 respectively, being secured in the closed position by multiple toggle locking gear. This gear is designed so that the doors can be easily released by hand when the material is under full pressure. Somewhat similar doors are fitted at the ends of the box, these doors, which are operated by hand levers and toggle gear shown in Fig. 3, being arranged to move outwards a few inches in order to facilitate the removal of the finished bale.

Inside the box, as shown in Fig. 3, is a movable platen carried by a riveted steel girder, the ends of which extend through slots in the ends of the box. Pulley blocks are mounted on the projecting ends of the platen girder, and corresponding pulleys are attached to the fixed head of the press frame. A flexible steel wire rope is reeved round each pair of pulleys as shown in Figs. 3 and 4, and one end of each rope is secured to the press frame, the other end being taken over pulleys to an electric haulage gear. By means of the gear, the platen can be hauled up to compress the material in the box, the maximum pressure exerted amounting to 25 tons in the case of the press illustrated. This load is distributed over 12 lengths of the rope which is of 2 in. circumference and has an aggregate breaking strength of 150 tons, so that the factor of safety is 6.

The haulage gear, as shown in Fig. 4, is mounted on steel channels extending from the frame of the press at the floor level. Fig. 5 is a section at the floor level showing the troughs formed to accommodate the ropes, the troughs being covered with loose boards as shown. The two winding drums of the haulage gear are driven by an electric motor through worm and spur reduction gearing, most clearly shown in Figs. 1 and 2. The spur gearing is machine cut and the worm gear, which is of the high-efficiency enclosed type, works in an oil bath; ball bearings are fitted on the worm shaft. The winding drums are of sufficient diameter to take the whole of the rope in a single layer, the rope lying in turned helical grooves on the surface. The motor, which is directly coupled to the worm shaft of the reduction gear, is of the totally-enclosed series, reversible type, and is capable of an output of 10 B.H.P. at 350 r.p.m. on intermittent rating. On light loads, and when lowering the platen, the motor speed increases to a maximum of 1,750 r.p.m., thus giving a high average speed of working. The time required to press a bale is about 1¼ minutes, and 1 minute, or less, is occupied in lowering the platen.

The motor is controlled by three separate push buttons marked "up," "down" and "stop," the necessary automatic switchgear, which is of the enclosed contactor type, being mounted in the panel shown in Figs. 1 and 2. A switch operated by the moving platen stops the motor automatically at the top and bottom limits of the travel of the platen, and a maximum current relay performs a similar duty when the full pressure is attained. The motor is prevented from running back and releasing the pressure when the current is cut off by means of a magnetic disc brake lined with "Ferodo." The brake is applied by springs and is only released when current is supplied to the motor.

The procedure for operating the press is as follows: With the platen in its lowest position and the doors closed, as shown in Fig. 1, the box is filled with sufficient material to form a bale. The "up" button is pushed to start up the motor, and the drums then wind in the wire rope, causing the platen to ascend until the material is tightly compressed against the top of the box. The motor then stops automatically, the brake maintaining the pressure as previously explained. At this stage the front and back doors are opened, as shown in Fig. 2, and the bale hooped or wired, and when this has been completed, the platen is lowered slightly and the easing doors released so that the bale can be removed. Provision is made for covering the bale with hessian or canvas in the usual manner. Presses of the same type are made in smaller and larger sizes capable of exerting pressures ranging from 10 tons to 100 tons, and suitable for any weight of bale.

AUTOMATIC CONTROL OF AN HYDRO-ELECTRIC GENERATING STATION.

An interesting long-distance and automatic control equipment is being installed in connection with the Johnson Falls Development hydro-electric generating station of the North-Eastern Power Company, of Wisconsin. The station is situated about 60 miles north of Green Bay, Wisconsin, and contains two 2,200-k.v.a. water-wheel generators, which will be operated over a telephone circuit from the High Falls station about 3 miles away. The control equipment is being supplied by the Westinghouse Electric and Manufacturing Company, of East Pittsburg, Pa., U.S.A.

At the High Falls station there will be installed a dial of the type usually found in automatic telephone systems. There will also be a telephone receiver, a reversing line key, and a loud-speaking telephone receiver for alarm purposes. At the automatic generating station there will be installed a 16-volt storage battery, together with a group of selectors for performing the various operations and setting up the necessary signals for the answer back. The connection between these two will consist of a single pair of copper-clad steel wires.

If the operator desires to ascertain the head of water at the automatic generating station, he will dial number 11 on the automatic telephone in the usual way. Before dialing, the line key is set to the operating position. Immediately after dialing, a single-stroke bell will be heard through the telephone receiver striking two single strokes separated by a slight interval, meaning 11, thus reporting back to the operator the fact that the selector in the automatic station has actually stopped on point No. 11. After the bell signal, the operator hears a series of buzzer notes which he counts—the largest number being 10. The total probable variation in water level is divided into 10 divisions, each buzzer tone indicating one division; thus, if the water were at half the normal head, the operator would count five buzzer tones, then by adding the base height of water plus five times the amount of each step, the actual height of the water will be known.

If the amount of water in the forebay is sufficient to operate one machine, the operator clears the line by opening the line key, then immediately closes it and dials No. 7 to start machine No. 1, or No. 8 to start machine No. 2. Before the actual starting operation takes place, the single stroke bell will sound seven or eight strokes as the case may be. If the operator finds that he has got a different point than the one he desired, he opens the line key, thus resetting the selectors to zero, and is ready to start again. If, however, the correct number of strokes are counted, the line key is left in the closed position for a few seconds and the desired machine will be started and thrown on the line. If it is desired to stop either machine, two other code numbers—9 and 10—are provided.

The automatic control is so designed as to start the machine and put it on at full gate opening. If the operator decides that the load cannot be carried with the amount of water available, he can reduce the load by dialing the proper number. For instance, if machine No. 1 has more load than can be carried, he will dial No. 3, and, upon listening, will hear three strokes of the bell, indicating that the proper operation will take place, after which the pilot motor on the governor will be operated for a few seconds. Immediately after the short period during which the governor motor operates to reduce the load, the selector is automatically connected to a code signal device which signals the position of the gate in the water-wheel by means of a series of 10 buzzer tones in the same manner as the height of water is indicated, each buzzer tone indicating one-tenth of the total gate opening. If the load has not been reduced by a sufficient amount, the line key is opened and closed and the same number dialed again, upon which the same sequence will be obtained and the load will be reduced still further. If the load is reduced too much, another number, in this case No. 1, for increasing the load on machine No. 1, will be dialed with the same result as before, except that the load is increased instead of decreased. Another pair of numbers—5 and 6—are provided if it is desired only to read the gate opening on either of the two machines without causing any change in the load.

In case anything happens in the automatic station of an abnormal character, such as the machine shutting down on overload or falling out for any reason, a high pitched warning tone is put on to the telephone line and sounds to the operator from the loud-speaking receiver. To stop the operation of this signal, another number, 12, is provided. If, after the operation of the warning signal, it is desired to ascertain what has caused its operation, a number, 13, is provided which will connect in the circuit a slow-motion selector which will test each safety device in succession on the two machines. The operator keeps track of the number of the operation and recognises the condition by the tone of the signal. A low-pitched buzzer signal will indicate normal operation, while a very shrill, high-pitched tone will indicate trouble. By counting the number of indications given, the number of the particular step which gives the abnormal signal can be ascertained and then, by consulting the reference list, the actual piece of apparatus in trouble can be identified by the operator, so that in notifying the maintenance man of the trouble, he can also tell him exactly where to look for it. If, for instance, the station is in full operation and No. 2 machine should get hot bearings and shut down, the warning signal would be put on the line. The operator would immediately dial No. 13 and listen in on the receiver. Assuming that the bearing thermostat on machine No. 2 is assigned No. 10 on the list of apparatus, the operator would count from one to nine low-toned buzzer signals, but at the tenth signal would hear a high-pitched buzzer tone. Referring to his list he would see that this indicated bearing thermostat trouble and would immediately send a maintenance man, properly equipped, to the station to investigate the oiling system and bearings of machine No. 2.

EVAPORATION AND DISTILLATION.

To the Editor of Engineering.

Sir,—The detailed report of the discussion at Glasgow on Professor Hinchley's paper on "Evaporation," in your issue of July 28, attributes to him statements respecting the limits of jet heat pump efficiencies, which the present writer feels certain are misquotations. Professor Hinchley is represented as stating (*a*) that the heat efficiency of the injector can only be about 20 per cent, and (*b*) that he could not see how it was possible for the heat pump to be as efficient as a quadruple effect evaporator.

In 1914 a single-effect evaporator made by the writer's firm was supplied to the Centrales Electriques des Flandres for evaporating a particularly impure water for feed purposes. The official tests of the plant, on which acceptance was based, gave the following results:—

Temperature of cold feed	30 deg. C.
Amount of distilled water per hour at 100 deg. C.	1,164 kg.
Amount of live steam used per hour	236 kg.
Pressure of live steam	192 lb. gauge.

Chemical analysis showed the distilled water to be quite pure, so that the actual performance was 4·93 lb. of water per pound of steam used, or a net gained output of 3·93 lb. per pound of steam. The plant works at atmospheric pressure, and there is therefore no vacuum or extraction pump. This result is superior to that produced by any quadruple effect vacuum apparatus.

Regarding the jet efficiency, it is difficult, without the context, to understand what Professor Hinchley meant by the expression "heat efficiency." In the form of combining jet used by the writer's firm the ratio of the total heat of the mixture, to the sum of the total heats of the live and entrained steams, never falls below 91 per cent., although, as the above test shows, a remarkably high entraining power is still retained.

Yours faithfully,

Jas. B. Maclean.

2, Central Buildings, Westminster, S.W. 1,
August 2, 1922.

[In fairness to our correspondent we print the above letter. In our abstract of the paper referred to (which was restricted in length under the regulation of the Chemical Engineering Group) the words mentioned were, our representative informs us, sensibly those used in the lecture of Professor Hinchley, whose paper was not read in full, and they were also used by contributors to the discussion. In Professor Hinchley's paper as printed by the Group the wording is "Provided that the temperature rise is small, not over 5 deg. C., the efficiency of the 'heat pump' is sufficiently good. By the turbo-compressor, about 10 per cent. heat efficiency is obtained, and by the injector over twice this amount." If the chemical engineers of this country underestimate the efficiency of this system the publishing of complete details of such tests as referred to by our correspondent might do much to remove their doubts.—Ed. E.]

The Effect of Lighting on Output.—During the past year M. Luckiesh of the Nela Research Laboratories has been investigating the effects of higher intensities of illumination on the speed of reading, and has found a definite increase of "speed of vision" as the illumination intensities increased. For ordinary reading matter (black print on white paper) the speed of reading increased 15 per cent. when the illumination increased from 4 ft.-candles to 16 ft.-candles. For black print on gray paper, the increase in speed was 50 per cent. when the illumination intensity increased from 4 ft.-candles to 16 ft.-candles. These data show the value of increasing the intensity of illumination, and the results can be safely extended to cover many other visual processes in the factory, the office or the home.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—A general resumption in the heavy sections following the holiday set-down will not be made until next week. Rolling mills, forges and foundries in general have more work on their books than two months ago, and have slightly increased staffs, but can comfortably meet all requirements by working rather less than half-time. Recovery is slow and very gradual. Efforts are being made to reduce production costs to a still lower level. The suspension of association quotations in steel-making and the return of a free market are expected to produce lower prices all round. There is considerable competition already in new business in common steels, though Sheffield is largely untouched by the operations of the bulk steel trade, its principal interest being in special alloy and tool steels. Recovery in special steels is disappointingly slow. The process of absorbing expensive stocks bought during the war appears to be endless, and although requirements in the automobile and agricultural industries are on a slightly higher level they are insufficient to alter the general appearance of the market. The dearth of orders on shipbuilding account is having a serious effect on the Sheffield heavy trades. Foundries producing castings and marine shafts find increasing difficulty in carrying on, and the outlook is anything but bright. Hope is more or less centred in electrical engineering. Several substantial orders are already in hand, but the principal developments on home and export account are still largely "in the air," and are not expected to materialise for several months to come. Big orders are pending for railway reconstruction, but the actual placing of new contracts is exceptionally slow. Orders for industrial plant, arrears of which have kept Sheffield moderately busy during the past three months, are nearing completion, and are being replaced very tardily. A more optimistic spirit prevails in the lighter section. Joiners' tools and builders' requisites are improving lines, and there is a readier demand, particularly on Colonial account, for mining appliances, machine tools, saws and planing tools. At the same time mass production plants have very thin order books and some disquieting rumours are in circulation respecting their financial position.

South Yorkshire Coal Trade.—Best steam hards are a moderately good market. Railway companies are building up reserve stocks at a satisfactory rate, and exports are moving rather more freely. Cobbles and nuts are still on the weak side; an early improvement is not expected. The scarcity of slacks has strengthened quotations; values are expected to rise until the pits work longer hours. House coal is going away very slowly both for local and metropolitan consumption. Furnace and foundry coke are still in fair demand, with prices firm. There is pronounced weakness in gas coke. Quotations:—Best branch handpicked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 27*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 22*s.*; Derbyshire small nuts, 16*s.* to 16*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Holidays have had the usual disturbing influence on business. As No. 1 Cleveland pig-iron and siliceous iron are as scarce as ever, these qualities continue to command 95*s.*, but other descriptions are in very ample supply, and rather easy in price. Home trade is quiet, and sales to the Continent are few and small, but business with America is expanding. Demand from the States is not confined to the special irons usually sold to that quarter, but includes inquiries for ordinary foundry pig-iron, and this month's Atlantic shipments promise to be rather large. Negotiations are also proceeding for sales of low phosphorus and low sulphur iron to the Pacific Coast. No. 3 G.M.B. is 87*s.* 6*d.*; No. 4 foundry, 87*s.*; No. 4 forge, 85*s.*; and mottled and white are 80*s.* All Cleveland pig-iron quotations are f.o.t. makers' works, and f.o.b. Tees.

Hematite.—East Coast hematite is plentiful, and producers are keen to secure orders. For home purposes up to 92*s.* 6*d.* is asked for mixed Nos., but customers state they can satisfy their requirements at below that figure. The export quotation for Nos. 1, 2 and 3 may be given at 90*s.* 6*d.* No. 1 hematite is now very little above mixed Nos.

Foreign Ore.—There is little or nothing passing in foreign ore. Sellers name 25*s.* as the c.i.f. Tees price of best rubio, but it is understood that orders would be accepted at 3*d.* less. Good Mediterranean ores are in the neighbourhood of 23*s.* c.i.f.

Blast-Furnace Coke.—Durham blast-furnace coke is fairly plentiful. There is a moderate demand for local consumption and average qualities are obtainable at 26*s.* 6*d.* delivered.

Manufactured Iron and Steel.—There is rather more doing in these industries. Renewal of some little interest in the market for shipbuilding material is gratifying, and it is pleasing to hear of a brisk business having been put through in galvanised sheets. With steel free from price restrictions once more, it is difficult at the moment to fix quotations, but keen competition for orders seems likely to lower rates. Already steel plates have dropped 20*s.* At present the following prices are asked for home trade, but steel offers at less—excepting for plates—would readily receive favourable consideration:—Common iron bars, 11*l.*; iron rivets, 12*l.* 17*s.* 6*d.*; steel billets (soft), 7*l.* 15*s.*; steel billets (medium), 8*l.* 5*s.*; steel billets (hard), 8*l.* 15*s.*; steel ship, bridge and tank plates, 9*l.*; steel angles, 9*l.* 10*s.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 10*l.*; heavy steel rails, 9*l.* 10*s.*; black sheets, 12*l.*; and galvanised corrugated sheets, 16*l.* 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Prices Reduced.—Conditions in the Scottish steel trade, which have been very poor for some months past, have shown little signs of improvement since the holidays. A few orders have certainly been booked of late, but these were not of heavy tonnage and will only help to keep plant partially employed. With a number of the shipyards still closed there is little demand for plates, but sectional material is a shade better. In order to stimulate business the Scottish steel-makers decided at the end of last week to cut prices by 15*s.* to 20*s.* per ton, from Monday of this week, for prompt specifications. Some buyers are of opinion that the reduction might have been on more generous lines, but it cannot be overlooked that fuel—one very important item in manufacturing—does not exhibit any easier tendency at present. The new basis prices are as follow:—Boiler plates, 12*l.* 10*s.* per ton, a reduction of 20*s.* per ton; ship plates, 9*l.* per ton, a reduction of 20*s.* per ton; sections, 8*l.* 15*s.* per ton, a reduction of 15*s.* per ton; and sheets, ¼ in., 10*l.* 5*s.* per ton, a reduction of 20*s.* per ton, all delivered Glasgow, and for home consumption only. The export price of boiler plates has been cut by 30*s.* per ton. It is too soon yet to say what effect these reductions will have on business, but increased bookings are expected. For black sheets the demand for the lighter gauges has shown an improvement, and there is rather more doing in galvanised sheets which have advanced 7*s.* 6*d.* per ton, making the price of 20-gauge, plain or corrugated, 16*l.* 12*s.* 6*d.* per ton delivered Glasgow, or f.o.b. Glasgow. The general export trade is opening out very slowly, but sellers are hopeful of an early improvement, and if the "freeing" of quotations, which is probable, is definitely fixed there will be some keen competition for the business on offer.

Malleable Iron Trade.—The malleable iron trade of the West of Scotland is still very poor, and movement is extremely slow. Few contracts are being booked, but there is a fair number of export inquiries in the market. The price of "crown" bars is unchanged at 10*l.* 10*s.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—There has been little change in the conditions ruling in the pig-iron trade of Scotland, and the demand overall for home consumption is not very heavy. In one or two instances there is a fair amount of business passing for foundry grades, but hematite is very idle. Quotations are as follow:—Foundry iron, No. 1, 4*l.* 17*s.* 6*d.* per ton, and No. 3, 4*l.* 12*s.* 6*d.* per ton, ex makers' yards; and hematite, 5*l.* 8*s.* 9*d.* per ton, delivered at the steel works.

Shipbuilding.—The scarcity of shipbuilding orders on the Clyde has been very severely felt in the Port Glasgow area, and there is extremely little work going on there now with the consequent result that much unemployment exists in that area. With the idea of giving some relief Messrs. Lithgows, Limited, the well-known shipbuilding firm have come forward with a proposal which is worthy of commendation. They are prepared to lay down four large cargo steamers, almost immediately if their workmen will accept pre-war rates of wages, plus any bonuses and advantages to which they and other workers may be entitled. The men have the proposal under consideration and have been given a certain date for a definite reply. Should the reply be in the negative the offer will be withdrawn or held up indefinitely, but if accepted it will mean employment for about 2,000 men at quite satisfactory wages.

THE INSTITUTION OF ELECTRICAL ENGINEERS: A.M.I.E.E. EXAMINATION.—It is proposed to hold the Associate Membership Examination of this Institution in London and at other places (at home and abroad) at the end of October, 1922. Entry forms and full particulars can be obtained from the Secretary of the Institution, Savoy-place, Victoria Embankment, London, W.C. 2.

A NEW THREE-ELECTRODE LAMP.—In a paper recently communicated to the Paris *Académie des Sciences* M. Maurice Leblanc describes a three-electrode lamp in which the current is conveyed by ions instead of by electrons, the bulb being charged with mercury vapour. The lamp has an iron anode, whilst the cathode is a drop of mercury between which and an auxiliary anode a current is kept continuously passing. Between the cathode and main anode is placed the third electrode in the shape of a grid, which can be connected up to one or other pole of a battery. If whilst the current is passing, this grid is rendered negative with respect to the cathode, it covers itself with a layer of positive ions which annul the effect of the negative charge so that the main current continues to flow. If, however, this main current is once interrupted, the grid becomes negative and prevents any further emission of electrons from the cathode, so that the current cannot be re-established again so long as the grid remains negative. To renew the current between the main anode and the cathode it is accordingly necessary to render the potential of the grid zero or positive. M. Leblanc has used the device for transforming a continuous current into a high frequency alternating current by interposing in the main current a resonator consisting of a self-induction and a capacity.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—American and Canadian business continues the chief interest of coal operators in South Wales. Inquiries for supplies of both anthracite and steam coals continue numerous, and up to the present it is estimated that orders for between 1,000,000 tons and 1,500,000 tons of Welsh coal have been placed for shipment by the end of September. At any rate 100 vessels to carry 654,000 tons of coal have been actually reported as chartered on the open freight market, in addition to which a large number of vessels have been fixed or allocated by the United States Shipping Board to lift coal. At the docks, loading operations are in full swing, but the capacity of the loading appliances is insufficient to keep all the collieries working regularly, with the result that temporary stoppages are taking place because of wagon shortages. Cargo exports of coal in July from South Wales amounted to 1,907,500 tons or 33,000 tons less than in June when there were three more working days. In July shipments to France amounted to 613,700 tons, to Italy 325,300 tons, to South America 211,000 tons, to Spain 158,700 tons, to Portugal 74,900 tons, to British coaling depots 117,600 tons, and to other countries 376,000 tons.

Iron and Steel.—Exports of iron and steel goods in the past week totalled 13,000 tons, compared with 7,400 tons in the previous week. Of the total, tin plates comprised 6,000 tons, iron and steel 4,497 tons, black plates 1,608 tons, and galvanised sheets 920 tons.

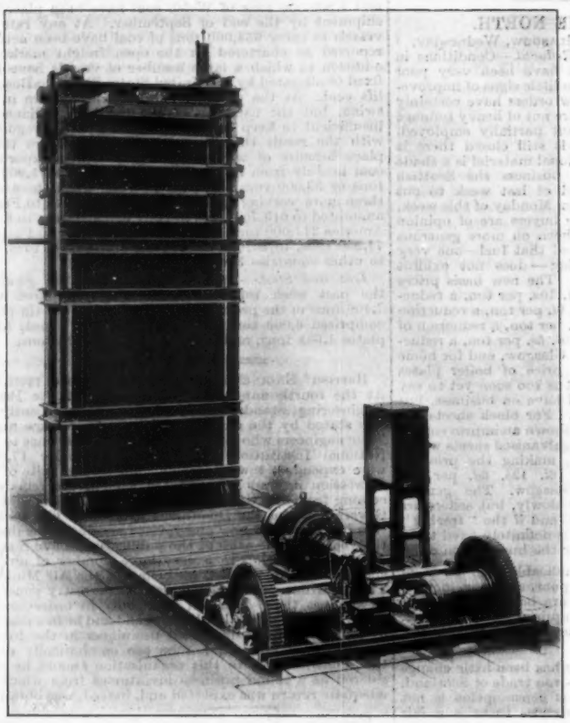
BRITISH ENGINEERING STANDARDS ASSOCIATION.—At the fourth annual general meeting of the British Engineering Standards Association, held recently, it was stated by the chairman that there are now nearly 2,000 engineers who give their time and experience to this National Institution. Last year just under 17,000*l.* were expended, towards which industry, in spite of the depression in trade, contributed 9,300*l.*, the remainder coming from the Government, the India Office, and the Governments of the Dominions overseas. The association has issued 72 new and revised specifications during the year, and the sales of the publications have reached 39,000, in addition to a very large number of aircraft specifications distributed on behalf of the Air Ministry. The chairman once again counselled industry generally to support the association financially in order that it might carry out the work it had in hand and be in a position to look forward to increased usefulness in the future. He said that it could not be too emphatically urged that contributions to this organisation should be considered as a sound business investment from which an adequate return was expected and, indeed, was obtained.

THE HULL MEETING OF THE BRITISH ASSOCIATION. PROGRAMME OF SECTION G: ENGINEERING.—The British Association will assemble at Hull on Wednesday, September 6, the meeting concluding on Wednesday, September 13. The president-elect, Sir Charles S. Sherrington, M.D., Pres.R.S., will deliver his address on "Some Aspects of the Animal Mechanism," on the Wednesday evening, in the City Hall. The programme of Section G: Engineering, which will also meet in the City Hall, under the presidency of Professor T. Hudson Beare, of Edinburgh, is as follows: Wednesday, 2.30 p.m., Organising Sectional Committee; the other meetings of this committee will be held at 9.30 in the mornings, before the sectional proceedings which will be opened at 10 a.m. Thursday, September 7: Discussion on "The Problems of Bridge Stresses," to be introduced by Mr. J. S. Wilson, of London; who will be followed by Mr. A. C. Cookson. Mr. Cookson will speak with special reference to the proposals of the Ministry of Transport; Professor B. P. Haigh and Mr. J. S. Wilson will speak on the "Influence of Rivet Holes on the Strength and Endurance of Steel Structures." A visit to the Canister Works of Messrs. Reckitt and Sons, Limited, will be paid in the afternoon. Friday, September 8: paper by Mr. G. V. Maxted, on the "Equipment of Modern Cement Works, with Special Reference to the Humber Portland Cement Company," a visit to which will be paid in the afternoon; paper by Professors F. C. Lea and R. E. Stradling, of Birmingham, on "Effects of Fire on Reinforced Concrete Buildings"; and a paper by Professor Lea on "The Testing of Building Materials"; presidential address by Professor Hudson Beare on "Some Australian Railway Problems." For Saturday morning, visits to the Hull Docks are being arranged. Monday, September 11: Discussion on "Economic Steam Production, with Special Reference to Marine Practice"; papers by Sir George Beilby, Mr. A. Spyer (of Messrs. Babcock and Wilcox, Limited), Mr. D. J. Harris (of the London and North-Western Railway Marine Department, Holyhead); in the afternoon, visit to the National Radiator Company. Tuesday, September 12: Paper by Mr. J. Richardson (of the Engine Department, Naval Construction Works of Messrs. W. Beardmore and Co., Dalmuir), on the "Propelling Machinery of the Cargo Carrier of the Future"; joint discussion with the Educational Section L, on "Reformed Teaching of Mathematics in Schools"; afternoon, visit to the works of the British Oil and Cake Mills, Limited. Wednesday, September 13: Paper by Mr. C. E. Stromeyer (Manchester on the "Resolution of Compound Stresses." Among other probable papers is one by Dr. Turner; there will also be a demonstration by Mr. R. S. Whipple (Cambridge and Paul Instrument Company), of the Collins Micro-Indicator for High Speed Engines. Mr. Charles Downs, local secretary of Section G, is in charge of the excursions. All communications concerning the Sectional transactions should be addressed to the Recorder of the Section, Professor G. W. O. Howe, Elmwood, Malden, Surrey.

ELECTRICALLY-OPERATED BALING PRESS.

CONSTRUCTED BY MESSRS. HINDLE, SON AND CO., ENGINEERS, HASLINGDEN, LANCASHIRE.

(*For Description, see Page* 176.)



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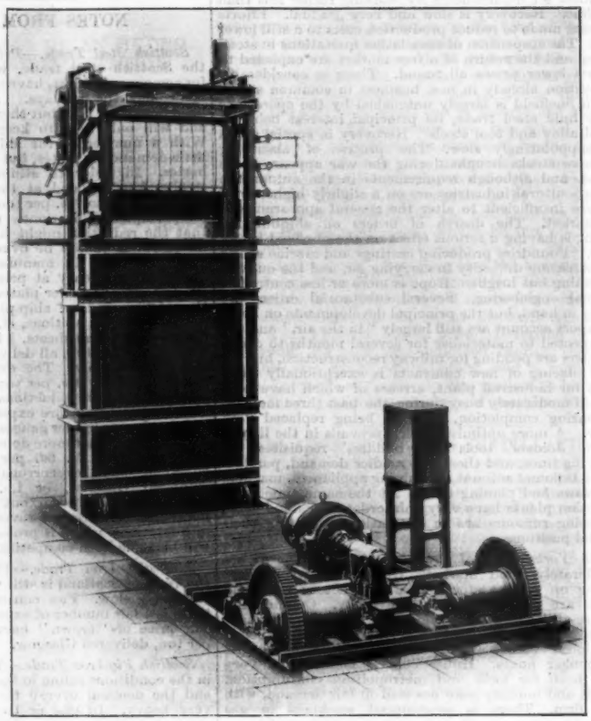
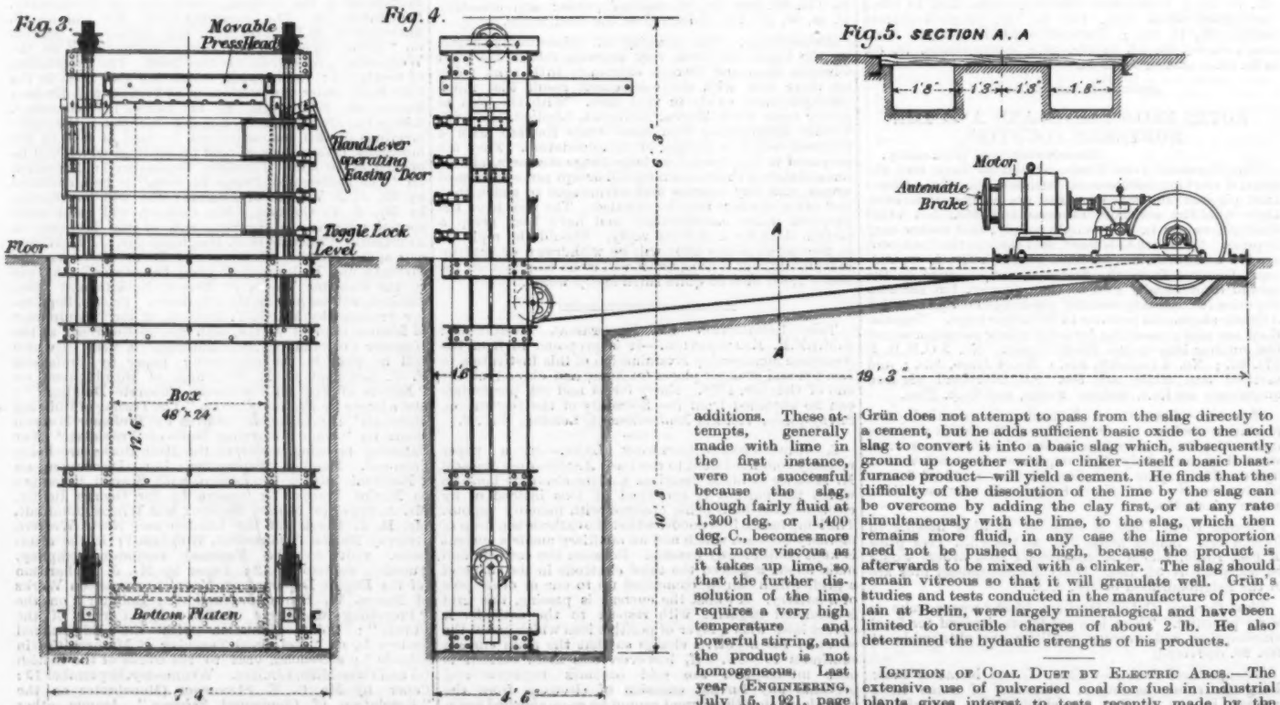


Fig. 2.



CONVERSION OF ACID BLAST-FURNACE SLAG INTO CEMENT.—Since blast-furnace slags and Portland cement are complex silicates of the same type, differing mainly by a deficiency of lime and clay in the slag, many attempts have been made to convert the still fluid slag, especially if acid, directly into a cement by adding lime and clay to the fused slag, which is to dissolve these basic additions. These attempts, generally made with lime in the first instance, were not successful because the slag, though fairly fluid at 1,300 deg. or 1,400 deg. C., becomes more and more viscous as it takes up lime, so that the further dissolution of the lime requires a very high temperature and powerful stirring, and the product is not homogeneous. Last year (ENGINEERING, July 15, 1921, page 103) we noticed the researches on slag manufacture in electric furnaces conducted in an experimental plant with Swedish acid slags, by K. G. Wennerstrom. The power consumption in these electric furnaces being high, in spite of their special construction, other Swedish firms interested themselves in the experiments of Dr. R. Grün (*Stahl und Eisen*, July 27 last, pages 1158 to 1167). Grün does not attempt to pass from the slag directly to a cement, but he adds sufficient basic oxide to the acid slag to convert it into a basic slag which, subsequently ground up together with a clinker—itself a basic blast-furnace product—will yield a cement. He finds that the difficulty of the dissolution of the lime by the slag can be overcome by adding the clay first, or at any rate simultaneously with the lime, to the slag, which then remains more fluid, in any case the lime proportion need not be pushed so high, because the product is afterwards to be mixed with a clinker. The slag should remain vitreous so that it will granulate well. Grün's studies and tests conducted in the manufacture of porcelain at Berlin, were largely mineralogical and have been limited to crucible charges of about 2 lb. He also determined the hydaulic strengths of his products.

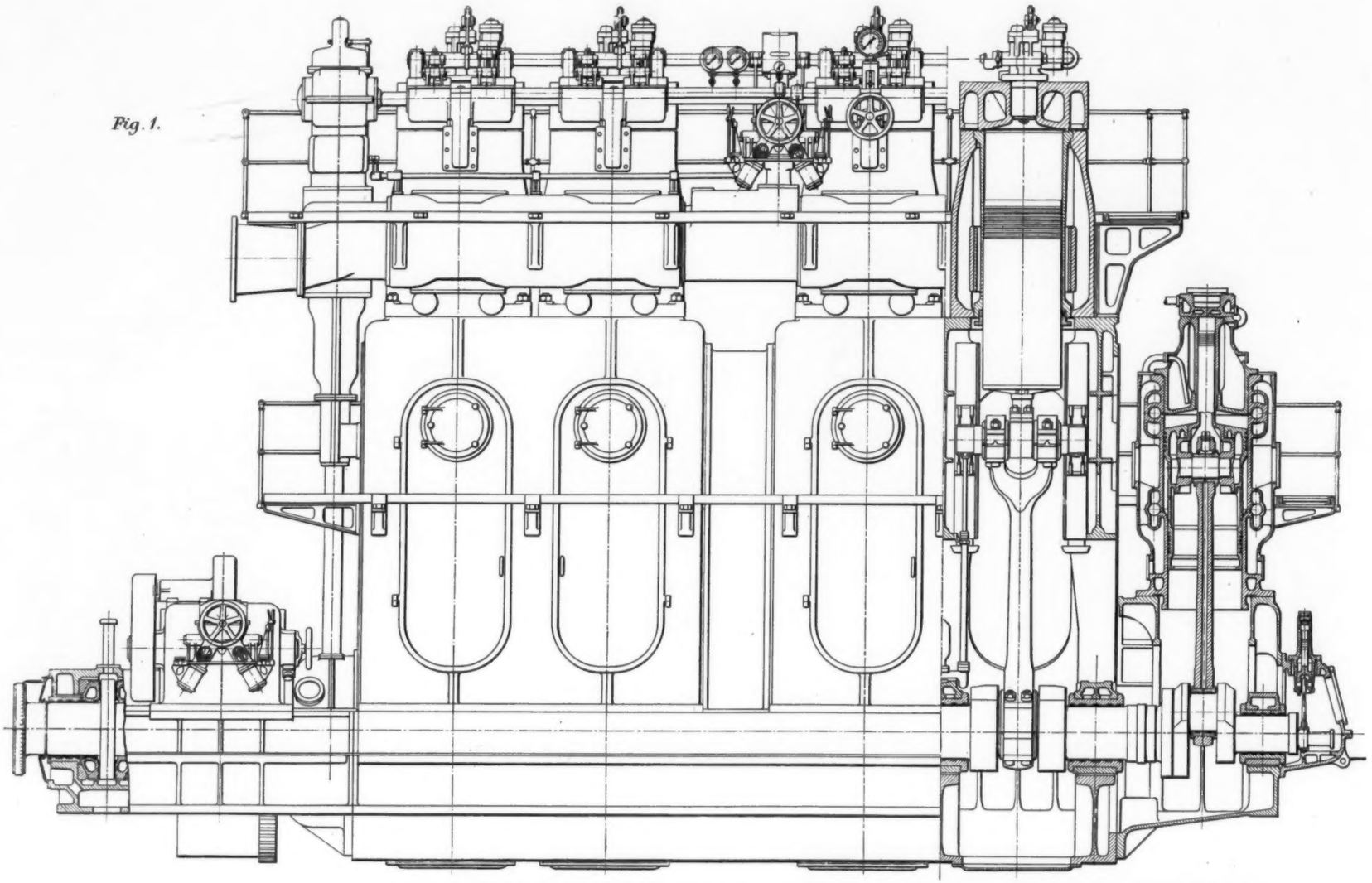
IGNITION OF COAL DUST BY ELECTRIC ARCS.—The extensive use of pulverised coal for fuel in industrial plants gives interest to tests recently made by the United States Bureau of Mines, which proved that coal dust suspended in air can be exploded by electric arcs under conditions that might prevail in a pulverised coal plant or in a coal mine. If there is electrical machinery in places where coal dust is apt to collect in quantities capable of producing a dust cloud, such electrical machinery should be housed in compartments designed especially for use in dusty atmospheres.

1350-B.H.P. TWO-CYCLE MARINE DIESEL ENGINE.

CONSTRUCTED BY MESSRS. SULZER BROTHERS, ENGINEERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 169.)

Fig. 1.



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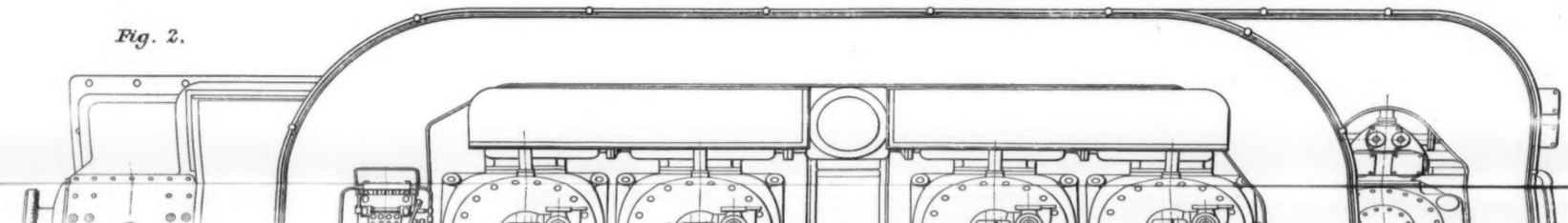

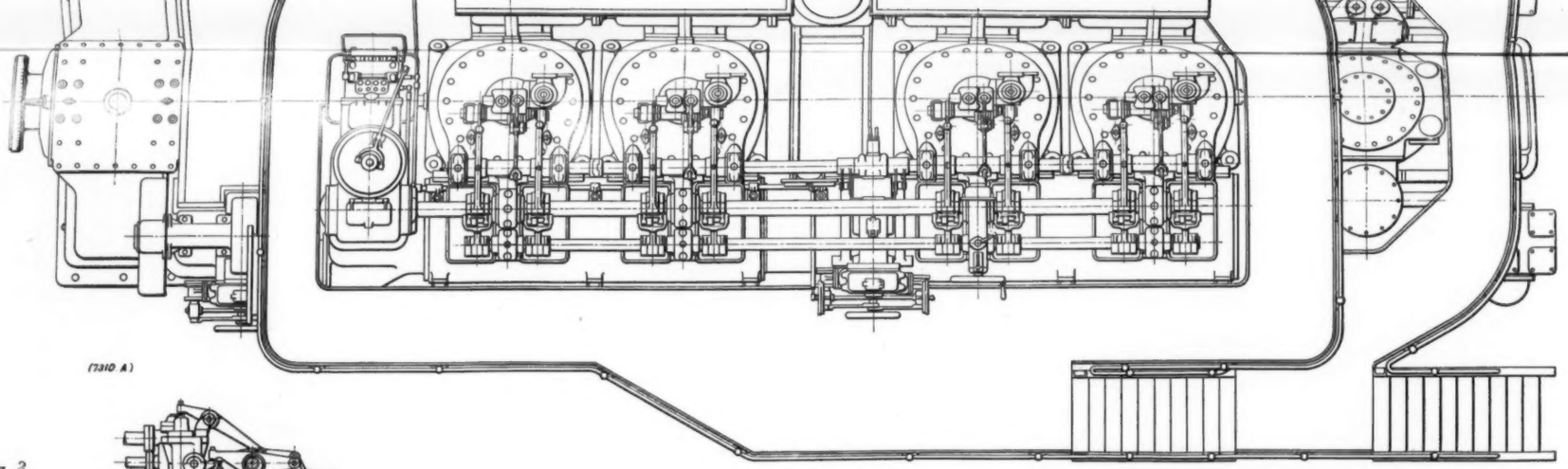

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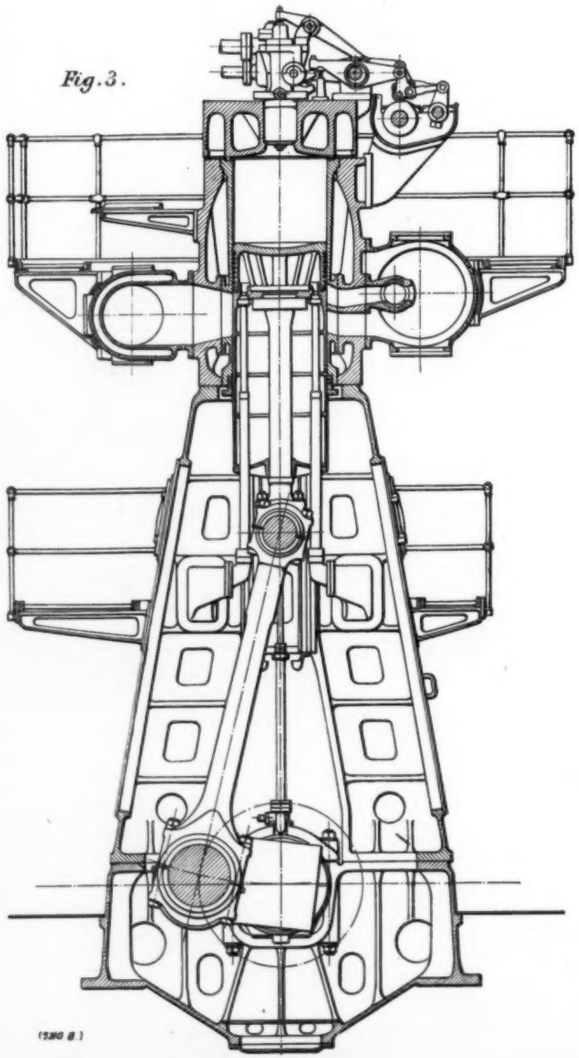
Fig. 3.



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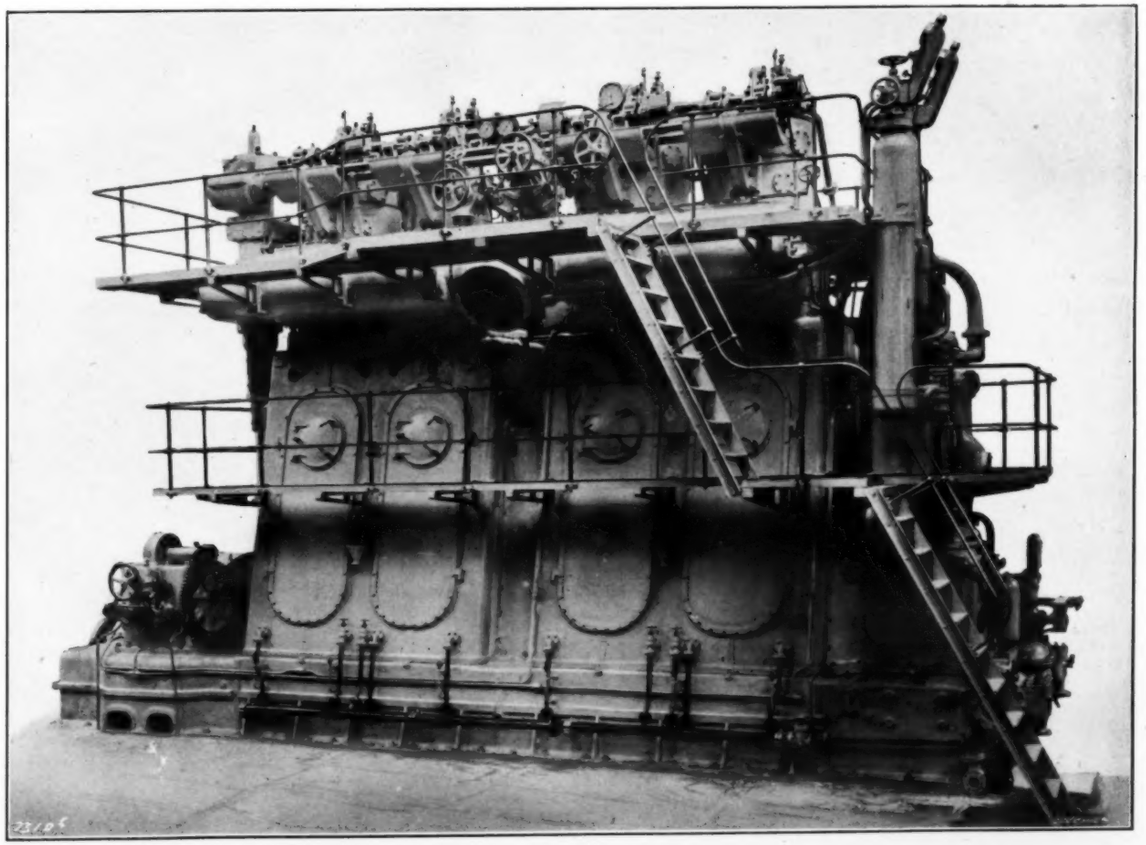

FIG. 4.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

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UNITED STATES: For Subscription, New York: W. H. Wiley 432, Fourth Avenue. For Advertisements: J. S. Allan 30, Church-street, New York.

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Two-Page Plate.—1350-*B.H.P. TWO-CYCLE MARINE DIESEL ENGINE.*

ENGINEERING.

FRIDAY, AUGUST 11, 1922.

THE REDUCTION GEAR PROBLEM.

THE discussion on marine reduction gears at the April meeting of the Institution of Naval Architects conveyed the impression that tooth fractures were in the main due to defective material, whilst excessive wear was to be attributed to dynamic action, arising either from cyclical variations in the propeller torque or from defective tooth cutting. The obvious remedy for oscillations due to variations in the torque lies in the provision of some form of damper, such as has been applied with great success to the elimination of trouble from the torsional oscillations of the shafts of motor car engines and of Diesel engines. Defective tooth cutting is more difficult to remedy. It is nevertheless interesting to note that Messrs. Ljungström have now running gears having teeth the flexibility of which is sufficient to compensate effectively for small errors in pitch. To this end deep grooves extending far below the base circle have been cut between successive teeth, so that each tooth is carried on a long and flexible arm or plate. The method involves, of course, an increase in the bending stresses on the material, as estimated from a static load, but it is quite possible that the actual maximum bending stresses are not higher than with normal teeth, owing to the diminution of shocks by the flexibility provided. It has, moreover, to be noted that in marine reduction gears, the bending stress on the teeth is generally very low, as it ranges from some 4,000 lb. per sq. in. up to about 8,500 lb. per sq. in. as a maximum. Considering the high quality of the steel used even the latter figure is small, although no doubt the enormous number of repetitions of the stress during the life of a gear is sufficient justification for a high factor of safety.

At the meeting, to which we have referred above, the all important point was, however, established that many "no trouble" sets of double reduction gearing were actually at work. The fact that these successful installations exist throws the responsibility for such failures as have occurred on the shoulders of makers and designers. Admittedly single reduction gears have been almost uniformly satisfactory, but the introduction of the double reduction system was soon followed by reports of bad behaviour, of excessive wear and of occasional smashes. Nevertheless Commander Tostevin's testimony that out of some 45 destroyers fitted with double reduction gears, trouble occurred with two only, suffices to show that the system is inherently sound, and that the proper policy is not the elimination of gearing and the return to reciprocating engines, as suggested in some quarters, but the careful study of the cases of failure with a view to ascertaining and eliminating the causes. In the case of the two failures mentioned by Commander Tostevin, the gears ran quite satisfactorily when the pinions first provided were replaced by others more carefully cut.

Absolute perfection in gear cutting is, of course, impossible, and the cost of a gear increases rapidly as the standard of perfection is raised. The evidence brought forward at the meeting indicated that an important aid to good running was the use of a flexible shaft between the turbines and the pinions. The angular momentum of a turbine rotor is enormous, and its speed may be considered as almost absolutely constant over such small intervals of time as are involved in the passage of a tooth in or out of gear. With a rigid pinion shaft any imperfection in the tooth form must accordingly be compensated for by a variation in the thickness of the oil film between the teeth, or by changes in the speed of the driven wheel. But even at relatively low loads the thickness of the oil film, in the neighbourhood of the point of contact, is of the order of $\frac{1}{10,000}$ of an inch, so that there is not much room for adjustment there. Nevertheless some minute amount must occur, but any diminution in the film thickness means much more than a proportionate increase in the pressure in the film, and there seems reason to believe that the pitting and wear of gear teeth is in the main an hydraulic phenomena. Calculation of the pressure developed in the oil film of a gear running with a pitch line speed of 50 ft. per second has shown that with quite moderate loads the hydraulic pressure developed in the film is over 3 tons per square inch, the least thickness of the oil film being about $\frac{1}{8,000}$ in. Lord Rayleigh and others have, however, shown that a film only two or three molecules thick, or, say, about $\frac{1}{40,000,000}$ of an inch, is capable of acting as a lubricant, and lubrication should, therefore, be perfect with a film $\frac{1}{80,000}$ in. thick, which would contain in this thickness well over 1,000 molecules. The corresponding pressure developed would then be some 90 tons per square inch, or far in excess of the elastic limit of the material.

That intense hydraulic pressures of an intermittent type can cause pitting, and wear has been effectively shown by Sir Charles Parsons and Mr. S. S. Cook, who proved that dynamic pressures due to the collapse of cavities in the water, were responsible for some serious cases of propeller erosion. It is therefore not necessary to assume that when teeth wear, metallic contact must have taken place. In fact, when a reasonable supply of lubricant is provided, it is difficult to see how actual metallic content can occur. As Mr. Deeley has shown, a good lubricating oil appears to weld itself to the metallic surface. No doubt the oil might have its constitution destroyed by the intense local heating which would arise were the film sheared only a few molecules thick, but owing to the intermittency of the action, the conditions in the case of gearing are very favourable to the conduction of heat away from the film, and it would be more difficult for a high temperature to be reached than in the case of the oil film in an ordinary journal bearing.

This question as to whether the wear is due to metallic contact or to hydraulic pressure has an important bearing on the variation of the permissible load on gear teeth with the diameter of the pinion. Taking merely static conditions into consideration Mr. J. H. McAlpine, in a paper which we published in our issue of July 14 last, on page 58, claims that the loading should vary directly as the pinion diameter, but he apparently ignores the part played by the lubricant. If we take two gears one to twice the scale of the other, then if the oil film thickness be increased in the same proportion the load carried per inch of pinion face will be exactly the same for the two gears. If, however, the permissible minimum film thickness is the same in the two gears, the larger pinion will carry double the load, which is

what Mr. McAlpine contends. The maximum hydraulic pressure developed in the oil film, however, will then be increased in the ratio of the square root of he scale and will thus, with the larger gear, be 1·4 times as much as with the smaller.

Mr. McAlpine claims that his view is supported by practical experience, but it may well be questioned whether the data are as yet sufficiently complete to settle the matter. No doubt (as was pointed out on page 601 of our issue of May 7, 1920) if the dominating factor is the shear on the oil film which tends to tear it away from the opposing surfaces then Mr. McAlpine's contention will hold. All recent data seem, however, to negative this supposition. In particular Mr. McAlpine on page 604 of our issue of May 27, 1921, states very definitely that pitting and excessive wear do arise without failure of the oil film, in which case the stresses which give rise to abrasion will increase as the square root of the scale and will not be independent of the scale as Mr. McAlpine contends.

The wear of modern reduction gears seems to be very similar in character to that experienced with the old mill gears so largely used in Lancashire. Here the teeth on the flywheel were commonly of about 5-in. pitch, the width of face being some 15 in. As with modern high-speed gears, the wear is found to occur mainly in the neighbourhood of the pitch line, and in trimming up these gears the fitters aim simply at keeping the teeth "off the points." It has been suggested that the cause of this localisation of wear is to be found in the fact that the relative motion of the two teeth at the pitch line is mainly one of rolling, whilst elsewhere there is a considerable relative slide. The originator of this theory assumed that in the case of a rolling motion, the lubrication was less efficient than when sliding occurs. In actual fact, however, the very reverse is the case, since calculation demonstrates that if a cylinder rolls over an oil-covered plane, the lubrication is twice as good as if it merely slid over it.

Experience certainly shows that with accurate gear cutting and careful workmanship, double reduction gears can be constructed to run satisfactorily. Modern machines and modern mechanics can, and do, turn out wonderful work, but, as we have already stated, the cost increases very rapidly with the standard of precision demanded. The very important question arises here as to whether this extreme accuracy is really essential. Writers on motor transport during the war tell us that the two cars which proved pre-eminently satisfactory in the operations in the East were the Rolls-Royce and the Ford. The success of the one was largely attributable to perfection of materials and workmanship, whilst that of the other was mainly due to its design, the car being for the most part the product of so-called semi-skilled labour. The design of the Ford car is such that road shocks are absorbed in the elasticity of the structure and are not transferred in their full intensity to vital points. It remains to be seen whether a corresponding policy may not provide a commercial solution of the gear problem. This, of course, is what Mr. McAlpine claims to have accomplished with his floating frame, and it certainly is noteworthy that the Westinghouse Company in America are working to values of K of as much as 360; whilst the highest value quoted in Commander Tostevin's paper read before the Institution of Naval Architects in 1920 is 220. The value of K multiplied by the square root of the pinion diameter gives the load transmitted per inch of wheel face, which is a perfectly definite and immediately intelligible figure. On the other hand Mr. McAlpine's "power constant" merely serves to fix the pinion diameter and affords *per se* no information whatever as to the load taken per inch of wheel face, which, as pointed out above, should almost certainly vary with the square root of this diameter.

Mr. McAlpine's rule, by which the loading is increased proportionately to the diameter, is based on the assumption, which is true for elastic solids, that geometrically similar bodies can carry the same loads per square inch of loaded surface. This rule, however, does not apply to lubricated surfaces, where, under geometrically similar conditions and with the same surface speed, it is the load carried per linear inch which is independent of the scale, and not the load carried per square inch.

Mr. McAlpine objects that in British practice a different rule for tooth loadings is used for small gears than for large ones. For large gears the load imposed increases as the square root of the pinion diameter, whilst for small gears the load has in some cases been made to vary directly as the diameter. No doubt the real reason for this peculiarity is the lack of sufficient experience to fix very definite limits to permissible loads, but it is easy to see, that if we had to deal with extreme cases, the procedure would be a perfectly rational one. Thus suppose the scale of a gear is to be reduced to one-sixteenth, then so far as dangers from abrasion are concerned the small wheel might carry one-fourth the load per inch imposed upon the large set. On the other hand were this done the bending stresses would be four times as great in the small scale model. Obviously a limit must be reached at which the safety of the gear will be fixed by the resistance of the teeth to bending and not by their resistance to abrasion. When this limit is reached, the load imposed should vary as the pinion diameter, whilst in larger gears where abrasion is the important factor, the load per inch of wheel face should vary as the square root of the scale.

HIGH ALUMINA CEMENTS.

At recent engineering conferences on the Continent a good deal has been heard of a class of cements differing from Portland cement by very remarkable, and what may prove to be, under certain conditions, valuable, properties. Though the cost of these cements is high, in the neighbourhood, we believe, of double that of Portland cement, there are numerous conditions under which increased first cost in material would be justified owing to this being offset by countervailing advantages to which we shall presently refer.

The work which has resulted in the production of the cements in question had its rise in the need of finding some binding material which would withstand the destructive action, on lime mortars and ordinary cements, of sulphates in earths or waters. Twenty or so years ago the attention of French engineers was attracted to several examples of failure in this connection, notably to the decomposition of mortar in the tunnel of Alicun, and the water channels on a neighbouring viaduct; and again to similar phenomena in tunnels at Rimont and la Plagnote, and also in structures on the Bou-Saada line in Southern Algeira. Though the way in which failure occurred differed somewhat in these instances, it was traceable in all to the presence of sulpho-aluminate of lime, which, in combining with water, on crystallisation undergoes an enormous increase in volume. Subsequent tests confirmed the destructiveness of sulphates on Portland cements, and the attempt was made to discover a suitable substitute. Working on lines suggested by M. Vicat's conclusion that a cement for which the ratio (silica + alumina) : (lime + magnesia) is greater than 1, will resist the action of sea water, M. J. Bied began experimental work with a view to increasing this ratio by raising the proportion of alumina. The aluminates of lime are four, namely, $3CaO, Al_2O_3$; $5CaO, 3Al_2O_3$; CaO, Al_2O_3 and $3CaO, 5Al_2O_3$. The first two of these are of little practical value owing to their extremely rapid setting in contact with water, but the last are valuable either pure or in the form of mixtures, and it is in connection with these that the work of M. Bied and others has resulted in material of practical utility.

In the United States, Mr. H. S. Spackman has had under consideration for some time the possibility of increasing the proportion of alumina in lime cements, and more recently in that country, Mr. P. H. Bates, of the United States Bureau of Standards has conducted independent studies of these cements, though on a comparatively limited scale. The conclusions of Mr. Bates, however, differ in certain points from other workers, as we shall show.

Mr. Spackman, in his investigations used mechanical admixtures prepared both by calcining and by fusing. Mr. Bates' work was also done with a small kiln. The commercial production of these cements in France at the present time is carried out either in a cupola, or in the electric furnace. It is for this reason that the products have acquired the trade names of "Ciment Fondu" and "Ciment Electrique," by which they appear to be commonly known, though M. Bied himself points out that such names are unsatisfactory for the cements as a class which should by preference be known by the general term "High Alumina Cements." Ciment Fondu is being commercially manufactured by the Société Anonyme des Chaux et Ciments de Lefarge et du Teil, with works at Teil, and also at Moutiers, Savoy; Ciment Electrique is manufactured by the Bureau d'Organisation Economique and the Société des Produits Chimiques d'Alais, Forges et Camargue, at Argentière la Bessée. Practically we understand fusion has proved more applicable than roasting, but it is clear from what we have said above that fusion is not essential to production.

As a result of Mr. Spackman's work in America alumina cements were made from slags from ores from Cuba. In France the materials employed consist of bauxite, schiste, limestone and slag. These ingredients are mixed, the mixture is then melted in the cupola or electric furnace, run off, cooled and reduced to powder. Normal analysis of the product shows about the following: Silica, 10 to 12; alumina, 40 to 45; iron or oxide of iron, 10 to 20; lime, 35 to 40. The resulting material has properties differing in a marked degree from Portland cement. In the first place the material does not decompose under the action of sea water, or in contact with earths or water containing sulphates. The material is slow setting, this action not commencing for two to four hours after mixing, so that ample time is secured for pouring and handling, and the adjustment of reinforcing bars, and so on. On the other hand once set, this cement hardens so rapidly that at the end of a few hours the strength exceeds that of Portland cement after several weeks. Setting is accompanied by a considerable rise of temperature—up to 175 deg. C. shortly after setting—while the action is said to proceed from the interior outwards.

As typical of tests showing the characteristics of alumina cements we may give the following: In tests of pure cement of this class, with the standard test-piece a tensile strength of 33 kg. was obtained at 24 hours, 59 kg. at 48 hours, 64 kg. at 72 hours, 67 kg. at 7 days, and 71 kg. in 28 days. A first-class Portland cement gave comparative figures of 10 kg., 22·5 kg., 33 kg., 50 kg. and 55·5 kg. respectively. A 1 : 3 mortar of high alumina cement gave, for similar periods, 29 kg., 34 kg., 35 kg., 36 kg. and 38 kg., the corresponding Portland cement mortar tests showing only 3 kg., 7·5 kg., 11 kg., 19·5 kg. and 27·5 kg. For concrete the superiority of the alumina cements is equally good, if not better than is shown by the above tests. For compression tests the results are even more interesting. In this case a block of neat alumina cement gave 470 kg. per square centimetre at 24 hours, 687 kg. at 48 hours, 743 kg. at 72 hours, 815 kg. at 7 days, and 959 kg. at 28 days—compared with 70 kg., 141 kg., 264 kg., 456 kg. and 612 kg. for neat Portland cement. In the 1 : 3 mortar alumina cement gave in compression 352 kg., 387 kg., 400 kg., 431 kg. and 475 kg., while Portland cement showed only 18 kg., 55 kg., 84 kg., 164 kg. and 287 kg. for similar periods.

The increased strength of high alumina cements is thus very marked. Especially is this so in the earlier stages of hardening. These are valuable features as will be readily appreciated. They enable lighter scantlings and weaker mixtures to be employed, while it makes the employment of cement or concrete more feasible in many cases in which jobs have to be completed with the least delay possible in order to minimise the interruption of normal routine. Further, it is possible to remove forms and shuttering so quickly that large economies are secured in this expensive item. The direct and indirect savings thus resulting are held to be such as often to more than warrant the extra price of these cements.

One point we may refer to here before we proceed to give some account of the class of work to which these cements have been applied. The practical

success of these cements depends, we understand, on the presence of just sufficient lime to form monocalcic aluminates. If lime is present in excess of the required proportion the cement acquires such a quick setting character as to be of little practical value. In working, therefore, it is essential to guard against contamination by Portland cements and lime, and appliances used for the latter must be thoroughly freed of these before use with alumina cements. It was probably partly due to this that these cements did not achieve any considerable success during the war. During that period their rapid hardening led to trials for work in the advanced trenches. Unfortunately, less was known about them then, and they were not treated with the care necessary, in transit and storage, and the results were unsatisfactory. With the return to normal conditions of construction it is possible to ensure handling these materials in a suitable manner, and their behaviour under the exceptional conditions at this front does not detract from their advantages in peace.

We could give a long list of works in which the material has been used to advantage, did space permit, but must content ourselves with a short summary. In many cases the gain by being able to remove the forms in the course of a day or two, instead of a month or six weeks, will be so obvious to our readers that we need scarcely do more than refer briefly to the character of the undertakings. On the Northern Railway of France these cements have been used for concrete buildings at Aulnoye, Lille, Tergnier, &c. In some instances the new works have been extensions or replacements of Portland cement concrete buildings. No trouble has been found in effecting sound joints between the new and old work. At Tergnier the work included a locomotive shed with reinforced concrete arch roof with 16 hanging concrete smoke jacks. In this instance the quick hardening properties were supplemented by the greater resistance to decomposition shown by this material under the influence of hot sulphurous fumes. In another class of work the job included the manufacture of 150 suspended chimneys, each about 22 ft. long, and weighing about 2 tons apiece. These were all uncovered within 48 hours of pouring the concrete.

At Lille the work in which these cement concretes have been used included several caissons, the largest of which measured 24·4 m. long by 7·25 m. wide by 7·55 m. high. Three days after pouring it was found possible to load this caisson with 200 tons of rails and bags of sand, and to commence sinking operations. Although difficult ground was encountered so that the caisson was temporarily deformed, no cracks appeared or permanent set occurred.

In driving concrete piles it is well known how inconvenient it is if on account of local causes some of the piles should prove too short and they have to be lengthened. Piles added to in the ordinary way have to mature for about a month before further driving, while in any case concrete piles must be prepared long before an undertaking can be started. Piles made, however, with high alumina cements have been driven three days after pouring without even protecting the heads. The saving in time thus possible, if lengthening has to be resorted to, will be apparent.

In the manufacture of concrete pipes, a repetition job, the following advantages have been found: A reduction in forms, and increase of output; a weaker mixture has been possible with reduced thickness and less reinforcing, resulting in reduced finished weight. Pipes have been delivered and laid the day after pouring. For transmission line standards similar savings in time and weight have been secured, the latter being of moment when, as is often necessary, the standards have to be transported for erection into the heart of mountainous districts.

The quick hardening properties make concretes of these cements suitable for pre-cast work, while pre-cast elements of ordinary reinforced concrete have been joined together in position with high alumina cements with success even in the case of tension members. As an interesting application in reconstruction the case of a bank may be quoted, where this cement made it possible to convert rapidly a complete floor of small rooms into a series of halls with large clear floor spaces, and considerable spans. Spans of 18 m. were introduced without difficulty, though it would have been impossible to bring into the building and manœuvre into place steel girders of that length. Further, Portland cement reinforced concrete would have involved obstruction of the normal work for too long a period. In this case the forms were removed in 48 hours, and the whole job completed without interfering with office work on the three floors above. Other applications in which advantages have been shown to be appreciable are machine foundations, tramline settings in streets, the cementation process for mine shafts, the rapid extension of buildings, quick repairs and so on.

Mr. Bates in his report suggests that high alumina cements are not suitable for use when subjected to the action of water. Moisture is essential while they are setting and hardening, and Mr. Bates' conclusion neither agrees with the opinion of Mr. Spackman or M. Bied, nor with practical experience in France. In numerous instances these cements have been used for work under water. In one case work was completed inside a compressed air caisson, the cement, mixed outside, being passed through the air lock, its slow setting quality allowing ample time for this to be possible. The work was successfully flooded two days later. In other cases water has been admitted to conduits almost immediately on completion. Owing to its resistance to decomposition it has been found suitable for marine works, while after exhaustive tests it has been employed by the Paris-Lyons-Mediterranean Railway for tunnel work in ground containing a large proportion of sulphates, in which no other cement had previously stood. We understand it has also been employed in tunnelling work for which the Administration des Ponts et Chaussées is responsible, other bodies having also used it with success. Slabs under test have, we may mention in conclusion, shown results far exceeding the requirements of the French regulations.

The development of these cements was to a certain extent stimulated by the high post-war price of coal, but, although this has now fallen, as a material for at least special forms of construction this class of cement appears to have established itself. In districts where power is cheap the electric fusion method of production has advantages. In many cases the overall savings have, we believe, been well established, while the economy in time is so considerable as frequently to become the determining factor in the situation.

BREACH OF A CONTRACT TO SUPPLY MACHINERY.

AT a time when delay in the performance of a contract to supply machinery is not uncommon, it is profitable to enquire into the rights of those who are parties to such contracts. Time of delivery may be of the very essence of the contract. The general rule as to the measure of the damages which must be paid for failure to deliver goods which have been ordered is laid down by Statute. Thus, by sec. 51, subsec. (3) of the Sale of Goods Act, 1893, it is enacted that "Where there is an available market for the goods in question, the measure of damages (*i.e.*, for non-delivery) is *prima facie* to be ascertained by the difference between the contract price and the market or current price of the goods at the time or times when they ought to have been delivered, or, if no time was fixed, then at the time of the refusal to deliver." It was held, however, in the case of Millett v. Van Heek, 37 T.L.R. 411, that the rule in the subsection that if no time for the delivery of goods is fixed, then the measure of damages is the difference between the contract price and the market or current price of the goods at the time of the refusal to deliver, does not apply to a case where the breach of the contract is an anticipatory breach by repudiation before the time for performance has arrived. In the case of such an anticipatory breach the measure of damages is the difference between the contract price and the market or current price at the time when the contract ought to have been performed, subject to abatement so far as the party claiming damages could have mitigated his loss.

It frequently happens that although in the first instance the time of delivery is declared to be of the essence of the contract, the parties agree to extend the time. In such a case the extension does not deprive the party complaining of further delay. Where, in the case of a contract for the sale of goods, which are to be delivered by a specific date, time is of the essence of the contract, and the vendor fails to deliver by that date and the purchaser after such failure elects not to avoid the contract, but agrees with the vendor to substitute a later date, the failure to deliver by such later date constitutes a breach of the contract. If the purchaser, having already re-sold the goods before delivery to himself, has to fulfil such contract of resale by means of other goods and thereby makes a greater profit than if there had been no breach, this fact does not reduce the damages which he is entitled to recover from his vendor. Sheik Mohammed v. Bird and Co., 37 T.L.R. 405.

Sometimes there is no market in which the goods which form the subject-matter of the contract can be bought or sold. The rule which is applied in such a case was restated in a recent case (Monte Video Gas and Drydock Company v. Clan Line Steamships, 37 T.L.R. 544). There the defendants contracted with the plaintiffs that they would carry a part cargo of gas coal to Montevideo and there deliver it to the plaintiffs. The defendants in pursuance of the contract carried coal to Montevideo, and there delivered it to the plaintiffs, but by mistake, the quantity of coal delivered was less than the contract quantity, and the coal delivered was steam coal and was not gas coal of the contract description. There was no market in which the plaintiffs could obtain gas coal in substitution for the steam coal delivered to them in any reasonable time. Held, that the plaintiffs were entitled to damages in accordance with the rule that where there was no market a plaintiff was entitled to recover the full amount of the damage which he had actually sustained by the breach of contract, subject to the general principle that such damage must have been within the contemplation of the parties. Distinctions between the liability of a carrier and that of a seller of goods depend on matters of fact and not of law.

It will have been noticed that in the case first above cited (Millett v. Heek *supra*) reference is made to the party "mitigating his loss." It is a principle of the law of contract that a man whose contract is broken must do all he can to minimise the damages. For instance, in the case of a sale of goods where the buyer refuses to take delivery, the seller is bound in all cases to take any reasonable steps which are open to him to reduce his loss, and if it is shown that upon the occurrence of the breach the seller might have gone into the market and sold to better advantage than he could have done by waiting until the contract date for delivery, his damages may, it seems, be reduced accordingly. Again, in the case of a servant who has been wrongfully dismissed before the end of his period of service cannot recover the wages for the whole unexpired period of service, including wages due at the date of dismissal, if he has obtained, or might have obtained, other occupation.

The principles here enunciated apply with equal force to a contract for the supply of machinery. In the case of British Westinghouse Electric and Manufacturing Company, Limited v. Underground Electric Railways Company, which was decided by the House of Lords in 1912, involved a discussion as to the measure of damages where the manufacturer has failed to provide a satisfactory machine. The material facts may be very briefly stated. In 1902, the British Westinghouse Company (who may be conveniently referred to as "the claimants") contracted to supply certain steam turbines and turbo-alternators to the Underground Electric Railways Co. (hereinafter called the respondents) for £250,000. Payments were to be made by instalments from time to time. Eight steam turbines and eight motor generators were delivered from 1904 to 1906, the respondents paying 159,439*l.* 3*s.* 2*d.* on account of purchase price. In spite of certain agreed reductions, a large balance of the purchase price was still outstanding when the

proceedings presently referred to were commenced. All the machines proved to be defective in design and efficiency, and failed to comply with the contract and specifications, but the respondents, while reserving their rights, continued to use them for supplying power to their railways. In 1907, the claimants, with the consent of the respondents, who still reserved their rights, removed and experimented with one of the machines with a view to seeing whether it could be put in order, but the experiments failed. Finally, the respondents made arrangements to substitute for the claimants' turbines, Parsons machines of different design and manufacture.

The claimants having sought to recover the unpaid balance of the purchase price, the matter was referred to arbitration. At the hearing before the Hon. Alfred Lyttelton, the respondents counter-claimed damages, and alleged that, as part of the damages they were entitled to the sums expended on the Parsons machines, as the purchase of those machines "mitigated or prevented the loss and damage which would have been recoverable from the claimants, if the respondents had continued to use the claimants' defective machines in the future." The claimants, on the contrary, alleged that as the commercial life of their machines had expired at the date of the purchase of the Parsons machines, no further damages were recoverable from them after the date when the Parsons machines were procured. The arbitrator stated a special case for the opinion of the Court upon these questions. The Lord Chief Justice, after reviewing the facts above set forth, said: "*Prima facie* it seems to me that the questions to be considered as to the measure of damages are (1) What would be the natural life of a properly-constructed machine, and (2) What would be the damages for having to work the defective Westinghouse machines? If the respondents had not put in the Parsons machines, the measure of damages would have been much larger. When a man is relying on breach of contract, he must do what is reasonable not to make the damages greater than they would otherwise be. Here the cost of the Parsons machines is a matter which the arbitrator must take into consideration. . . . It would not be right to adopt the contention that because Parsons machines had so much improved in 1908, 1909 and 1910, Westinghouse machines had come to an end of their commercial life."

What he found is stated by Lord Haldane in his judgment in the House of Lords (1912 A.C. at p. 688), where he says: "The arbitrator appears to me to have found that the effect of the superiority of the Parsons machines and of their efficiency in reducing working expenses was in point of fact such that all loss was extinguished, and that actually the respondents made a profit by the course they took. They were doubtless not bound to purchase machines of a greater kilowatt power than those originally contracted for, but they, in fact, took the wise course in the circumstances of doing so, with pecuniary advantage to themselves. They had, moreover, used the appellants' machines for several years, and had recovered compensation for the loss incurred by reason of these machines not being during these years up to the standard required by the contract. After that period, the arbitrator found that it was reasonable and prudent to take the course they actually did in purchasing the more powerful machines, and that all the remaining loss and damages were thereby wiped out."

It remains to consider how far the party in default is liable for consequential damages. In Cory v. Thames Iron Works Company (1868) L.R. 3, Q.B. 181, the plaintiffs bought from the defendants a patent boom derrick, the first of its kind ever built in this country. It was to be delivered in six months' time, and the defendants knew the plaintiffs were going to use it in their business. It was shown in that case that owing to delay the plaintiffs lost profits which they would have made in a contract with Sir W. Armstrong. These profits the plaintiffs sought to recover when it was pointed out that the special purpose was not known. Chief Justice Cockburn, however, observed, in the course of the argument: "There is one thing which must always be in the knowledge of both parties, which is, that the thing is bought for the purpose of being in some way or other profitably applied." This case, however, is an authority for the statement that the damages are not necessarily confined to that which both parties contemplated. They may be assessed on a larger basis than that. The principle is thus stated by Sir Henry Mayne, in his work on *Damages*—"Where, in consequence of a change of circumstances, the defendant's breach of contract has not produced full damage which the contract originally provided against, only the loss of which has actually been incurred can be recovered." Mayne also says: "As the damages for breach of covenant are measured by the actual loss or inconvenience which the plaintiff has been put to by the breach, his loss or inconvenience may from time to time vary or disappear. If, by lapse of time, change of circumstances, or from any other cause, the covenant, has ceased to operate or has wholly or in part lost its beneficial character, or if its breach has been acquiesced in to a degree short of that which would bar an action, a breach may come to be measured by very small or by merely nominal damages."

In Wigsell v. School for Indigent Blind (1882), 8 Q.B.D. 357, certain persons who had bought land upon which to erect a school, covenanted to build a wall 7 ft. high between it and the land of the vendor. Having failed to build the wall, the grantors brought an action for damages claiming the cost of putting up the wall as damages. It was shown that the fact of the wall not being built had not really affected the price of the plaintiff's land. In these circumstances it was held that, the true measure of damages being the pecuniary amount of the difference between the position of the plaintiffs upon the breach of the contract and what it would have been if the contract had been performed, under the circumstances of the case the amounts that it would cost to build the wall was not the true measure of damages. In that case, Mr. Justice Field said: "The rule stated in its most general terms is that plaintiff is entitled to have his damages assessed at the pecuniary amount of the difference between the state of the plaintiff upon the breach of the contract and what it would have been if the contract had been performed."

The courts of the United States supply some useful authorities upon the subject under discussion. In Jacksons v. Hurlbut (158 N.Y. 34) an action was brought to recover damages for the breaking of a planing machine while in custody of defendants, who were carriers, for transportation to plaintiffs' factory. There was a verdict of $500 for injury to the machine and loss of plaintiffs' use while being repaired. In the course of the judgment of an appeal court the following passage appears: "It was urged that the judge had admitted evidence to show loss of profits from inability to use the machine after the injury and until it was repaired. But no evidence as to loss of profits was given. Some proof was given that the plaintiff was compelled on account of the injury to the machine to send work out of the shop in order to complete contracts they had in hand at the time of the breaking of the machine. This was not proof of the loss of the profits, but of the loss occasioned to the plaintiff by inability to use the machine on account of the defendant's negligence. We are not prepared to say that this evidence was not entirely competent under the circumstances of the case, but it is not necessary to consider this question, as the expense of restoring machine in a condition to use was a proper element in the estimation of damages, and that item of expense alone exceeds the verdict. The item of the expense of restoring the machine to a condition that would render it fit for use is certainly within the principle that damages must be compensation for the actual loss sustained which was the natural and proximate consequence of defendant's act. The cost of procuring necessary work to be done outside factory in order to enable plaintiff to fill his contracts from inability to use machine would seem to be within same principle also." In Reynolds v. Braithwaite (131 Pa. 416) it was held that when one has work done for him under a contract, exercising control of the mode of doing the work, and participating in and approving the acts of the contractor which constitute the cause of action, he is responsible for injuries resulting to another from the lawful acts of the contractor.

In an action for damages for cutting a pipe line upon defendant's land supplying water to plaintiff's premises, it was held to be legitimate to instruct the jury that the plaintiff was entitled to the reasonable cost of obtaining a supply of water, and to the reasonable cost of the depreciation thereof, from the time it was cut off. Nor was it wrong to charge the jury that the case was one in which judgment would not necessarily be limited to mere compensation. It was not a case for punitive damages, but the jury would consider whether compensating damages would be sufficient punishment for the wrong.

In a well-known American text-book, *Sedgwick on Damages* (8th edition), (Vol. I., page 45, note (a)), it was stated that in an action (Davis v. Talcott, 14 Bart. 114) to recover damages for the defective execution of a contract to reconstruct and put up machinery in a flour mill in a well-finished and workmanlike manner, and of sufficient size and strength to correspond with the cylinders, the proper measure of damages is the difference between the value of the machinery actually put up and that agreed to be constructed. In such an action, the plaintiff is entitled to recover, in case the jury find that the machinery was not properly constructed, such sum as would be sufficient to put the same into condition contemplated by the contract; also such sum as the mill would have earned during the time it was necessarily delayed in consequence of the breakage in defects in the machinery, taking the fair ordinary earnings of the mill, after deducting from the gross earnings the expense of running the same, as the net profits. So, in case the contract is not performed in a reasonable time, the jury are to ascertain how long performance was unreasonably delayed, and then if they find the plaintiff was in a condition to work his mill, by having grain to grind, and is prevented from grinding the same by such unreasonable delay, the plaintiff is entitled to damages to the gross amount of the earnings of the mill, after deducting the expenses of the same. In another American case, Goodloe v. Rogers (10 La. Ann. Rep. 631), it was held that in a case where it might be implied to be in the contemplation of the parties to a contract that a sugar mill and engine, which the manufacturer undertook to put up within a given time was for the purpose of getting crop, it was held that a failure to put it up in time entitled the plaintiff to recover for loss of crop and extra wages caused by delay. In another case, where the lessors of a saw mill broke their contract to repair the mill, the lessees, who had a large stock of logs in the mill yard, were held entitled to recover the expenses of removing them to another mill and the cost of getting them sawn there. (Hinckley v. Beckworth, 13 Wis. 31). In another American case, it was decided that where defendant breaks his contract to supply property or to do work not by altogether failing to do the thing contracted, but by doing it improperly, the plaintiff can recover no more than the cost of remedying the defect. So, upon the sale of a machine which contained defects, where the defendant could have been recompensed by a small expenditure, it was held that this must be done and plaintiff could not receive damages based on a recurrence of the injury. (Frick Company v. Falk, 50 Kan. 644).

Again, where the breach of warranty of machinery makes it impossible to get something necessary for use, the purchaser must minimise damages by procuring it elsewhere. So where a steam pump to be used to pump water for a greenhouse fell short of warranted capacity, the purchaser must avoid loss by procuring water elsewhere. (Carter v. Fisher, 121 N.Y. Supp. 614.) Finally, where a machine was delivered in an unfit condition to do the work it was purchased for, the purchaser was allowed to recover the expenses of a reasonable but unsuccessful attempt to adapt it to the contemplated purpose (Whitar v. Ryder, 139 Mass. 366), and so, of course, of a successful attempt. (Jackson v. Hurlbut, 158 N.Y. 34.)

In conclusion it may be pointed out that

there is a distinction to be drawn between the sale of a piece of machinery as a chattel and a piece of machinery annexed to the freehold. In Underwood v. Burgh Castle Brick and Cement Syndicate Limited, 38 T.L.R. 44, the plaintiffs contracted with the defendants to sell to them an engine, which was fixed in the plaintiffs' premises, and was a trade fixture, and to deliver it "free on rail." The plaintiffs did not sufficiently dismantle the engine before its removal, and the result was that it was damaged when being loaded at the railway station. The defendants refused to accept it, and it was never delivered to them. Held, that as the detachment and dismantling of the engine were things which the plaintiffs were bound to do for the purpose of putting the engine into a deliverable state, the property in the engine did not pass to the defendants at the time of the contract, and that they were not liable for the price.

THE LATE DR. ALEXANDER GRAHAM BELL.

AMONG the great inventions of the nineteenth century, which have done so much to dictate the conditions of modern life, the telephone takes an important place, and it is likely that Alexander Graham Bell, by his work in connection with the instrument, has ensured himself permanent memory in the history of scientific and mechanical advance. From the purely sociological point of view the telephone is probably of less importance than the telegraph, but it is none the less difficult to conceive the state of a modern Western community if deprived of the instrument. This admission may suggest a defective imagination since Bell's first successful telephone was constructed as recently as 1876, but it is fairer to remember that the advances made in photography, telegraphy, telephony, prime movers, electrical work and aeronautics since that date have deeply modified the main part of the proceedings of Western mankind.

The death of Dr. Alexander Graham Bell, which took place at Beinn Bhreamgh, his summer residence near Baddeck, Nova Scotia, on the 2nd inst., raises memories of old controversies about priority in the invention of the telephone. Important early inventions were made by many workers, but it is certainly to Bell that we owe the employment of an iron disc clamped at the edge and vibrating in unison with the spoken voice, the vibration of the disc being used to vary the magnetic flux through a coil. The currents so generated are used to vibrate a similar disc at the far end of the line and so reproduce the original speech. The practical value of Bell's telephone was greatly extended by Edison's invention of the carbon transmitter about a year later, but it is remarkable that Bell's instrument differs in no important particular from the telephone receiver in common use to-day. Bell patented his telephone in America on February 14, 1876, and in this country on December 9 of the same year. Edison patented his invention of the carbon transmitter in America on July 20, 1877, and in this country 10 days later.

Although the telephone as we now have it owes its success essentially to the work of Bell and Edison and particularly to Bell, as he independently produced an entirely practical instrument both for transmitting and receiving, none the less important work was done by others. It is not necessary to attempt here any complete history of the telephone, but some mention may be made of early inventions since it is likely Bell had some knowledge of many of them and may possibly have been influenced in his work by what others had done. When a young man in London he met Sir Charles Wheatstone and Mr. Alexander J. Ellis, and from the latter learned of Helmholtz's work in connection with the vibration of tuning forks by electromagnets. Wheatstone himself, in 1831, had constructed a rudimentary mechanical telephone in which vibrations were conducted between two sounding boards through a rod of pine wood.

Before proceeding to the details of Bell's own work, reference should be made to the famous article by Charles Bourseul which appeared in *L'Illustration* of Paris, on August 26, 1854. This described a telephone in which a flexible plate, vibrating in response to varying air pressure, was used to open and close an electric circuit, the current pulsations being used to operate a similar plate at the receiving station by means of an electromagnet. It will be clear that this apparatus proposed an entirely different method from that used by Bell. It, however, had much in common with the telephone constructed by Philip Reis, who has been held by many, notably by the late Sylvanus Thompson, to be the inventor of the telephone. Reis used a membrane, the vibration of which opened and closed an electric circuit, the electric impulses acting on an electromagnet which gave out a sound corresponding to the number of times it was magnetised and demagnetised per second. This effect of an electromagnet had been pointed out by Dr. C. G. Page, of Salem, Mass., in 1837. It is stated that Reis' telephone reproduced the consonants "pretty distinctly," but that the vowels were defective. Reis seems to have considered only pitch and amplitude when dealing with the question of the transmission of speech, and to have overlooked the question of quality, or shape of the wave, altogether. It is difficult to believe that his instrument or his method could ever have formed the basis of a successful telephone system. This question of quality of sound was one not at all likely to be overlooked by Bell as he had been interested in it all his life.

Alexander Graham Bell was born in Edinburgh on March 3, 1847. His father and his grandfather were both teachers of vocal physiology and the laws of speech, so that Bell from very early years was interested in all matters pertaining to the human voice. When he was a boy his father told him about a talking machine he had seen, and the boy attempted to construct such a machine for himself, making a sort of artificial skull from rubber which produced sounds resembling simple words when it was blown into with a pair of bellows. When Alexander was 14 years of age he came to London, and was instructed by his grandfather in elocution and phonetics. He returned to Edinburgh to attend courses at the University and for a short time was a schoolmaster at Elgin. He was later, but still quite as a young man, assistant to his father, who had obtained a post as lecturer in elocution at University College, London. It was at this time that Bell met Wheatstone and Ellis and became interested in Helmholtz's work on the electromagnetic control of tuning forks.

In 1870 the Bell family emigrated to Canada for reasons of health. Alexander was delicate and two of his brothers had died from tuberculosis. The family went to Brantford in Ontario, but in 1871 Alexander obtained an appointment in Boston giving instruction to deaf and dumb children. He was 24 years of age at this time, and it was during the next few years that the invention on which his fame rests was worked out. He remained in Boston until 1881, when he removed to Washington, and it was in Boston that his vital work on the telephone was done. At no time during these years does Bell appear to have lost his interest in, or slacked in his study of, all matters bearing on the mechanism of speech, and he gradually worked towards his practical instrument. The basic idea of varying the electric current in terms of the vibration of a diaphragm, rather than interrupting the current as Reis had done, seems to have been behind all Bell's definite work on the telephone. In an early instrument the armature of an electromagnet carried an arm, a stud on the end of which pressed against a stretched membrane of parchment. Owing to the weight of the moving parts this did not prove successful and a piece of clock spring was substituted for the arm and was secured to the centre of the membrane. This arrangement was sufficiently satisfactory to show that the work was on the right lines, and as experiment showed that better results were obtained by increasing the size of the piece of clock spring which acted as the armature, Bell gradually arrived at the arrangement in which an iron disc acted both as armature and diaphragm. At this stage the modern telephone was achieved. Later work was in the direction of minor improvement, although, as we have said, the resemblance between a Bell instrument and a modern receiver is certainly remarkable.

In the early part of 1876 Bell was able to conduct satisfactory conversations with his assistant, Mr. T. A. Watson, between his laboratory and an attic at the University of Boston, and in the same year the instrument was successfully used over a telegraph line at Brantford. Bell's claims were at first received with considerable incredulity, but he seems to have received great assistance from the display of his instrument—which he made at the Centennial Exposition held in Philadelphia in 1876. The matter was brought to the eye of authority through the Emperor of Brazil, who saw the instrument and was greatly impressed by it. The instrument was also seen by Lord Kelvin (then Sir William Thomson), who brought an example to England and exhibited it before the British Association. As may easily be understood, the telephone was not immediately a commercial success. The patent was attacked by Reis, Elisha Gray and others on the score of priority, but ultimately Bell's claims were fully established and he was secure in one of the most valuable patents ever granted. A company was formed with the assistance of Mr. G. G. Hubbard, the father of Dr. Bell's wife, and later Mr. T. N. Vail assisted on the commercial side. The extent to which the instrument has now spread to every civilised country requires no dwelling on.

Although it is on his work on the telephone that the fame of Dr. Bell will rest, he did much oth r scientific work of an important character, and his interests were wide. He made many researches in connection with the transmission of sound by means of light by utilising the change in resistance of selenium when a varying light falls on it. The general lines of work of this class are well known. With the exception of the Optophone we are not aware that any apparatus depending on this property of selenium has proved of any important practical value, but the field would always appear to offer possibilities. Dr. Bell transmitted speech a distance of 213 m. by a beam of light from an instrument placed on the top of the Franklin school house in Washington. He found that articulate speech could be reproduced "by the oxyhydrogen light and even by a beam from a kerosene lamp."

Dr. Bell was also interested in mechanical flight and constructed at least two aeroplanes. The second, named Cygnet II, was tested in Nova Scotia in the year 1909. It was largely built of bamboo, and measured some 50 ft. from wing tip to wing tip. It was fitted with a 35-h.p. motor driving the single propeller through a chain. Like other early workers on the aeroplane, Dr. Bell was a believer in a cellular construction, and Cygnet II was built up with an enormous number of tetrahedral cells disposed over a slightly inclined plane. The work on this machine followed fairly successful flights as a kite of an earlier machine, Cygnet I, which was built on the same lines. This kite machine reached a height of 168 ft. in December, 1907, and remained aloft for 7 minutes. These were, of course, early days in heavier-than-air aviation, and Dr. Bell does not seem to have been actively concerned in the practical developments of the last ten years. He believed that the cellular construction would give stability and would allow of safe, slow flight.

Dr. Bell visited this country for the last time towards the end of the year 1920, when he received the Freedom of his native city of Edinburgh. He at that time attended a meeting of the Wireless Section of the Institution of Electrical Engineers, of which he was an honorary member, and spoke on the subject of wireless telephony. Dr. Bell was the recipient of many distinctions. He received the Hughes medal of the Royal Society and the Albert medal of the Royal Society of Arts. He was also presented with the French Volta prize, and with it established the Volta Laboratory at Washington for the study and investigation of the transmission and reproduction of articulate sounds. He had honorary degrees from various universities, including Harvard, Illinois and Heidelberg.

OUR FUEL RESERVES.—According to Arrhénius, British reserves of coal will be exhausted in 200 years, those of Germany in 700 to 800 years, and those of America in about 2,000 years. On the other hand he estimates that the mineral oil reserves of the world will be exhausted within the experience of some now living.

NOTES.

Pendulum Observations and Radiotelegraphy on Mont Blanc.

In 1899, Professor Jean Lecarme made some observations at the J. Vallot Observatory, which is situated near the top of Mont Blanc, about 450 m. below the summit. These observations were resumed recently with the further particular object of establishing a radiotelegraphic station there. (*Comptes Rendus*, May 29, pages 1413–1416.) The difficulties of making a prolonged stay on the top of the highest mountain in Europe, where the mean barometer height is 44 cm., instead of the 76 cm. at sea level, are, of course, very great. The high winds never fell during the whole eight days, from August 18 to 26 last year, which Lecarme spent in the Observatory, and severe atmospheric electric disturbances were common. To support life in the rarefied air, Lecarme found subcutaneous injections of oxygen very useful. In erecting his radiotelegraphic plant he adopted several interesting devices. Instead of stretching the wires in the air, where they would be exposed to the storms and liable to be weighted with ice and snow, he buried them so far as possible in the dry snow, which is an insulator; this expedient greatly reduced the coronal discharges. For the sake of further protection he inserted glass tubes, charged with a highly-rarefied gas of low resistance and self-inductance, and provided with two electrodes having large surfaces, in the antenna-earth circuit; these tubes would normally bear currents of 25 milliampere at 50,000 volts and would, by their glow, give warning of the approach of electric storms. To make the observations taken at the Observatory of scientific value, a very exact knowledge of the time is indispensable. Lecarme therefore took a pendulum clock and two chronometers, all tested for months, up to the Observatory, conducting observations first at Chamonix, at an altitude of 1,050 m., and then at the Observatory, altitude 4,365 m.; the summit is at 4,810 m. The second-pendulum, 1 m. in length, is made of a rod of invar and a lenticular bob of the same alloy, weighing 10 kg.; the oscillations are electrically maintained by the aid of a Féry battery of three cells, which can stand the cold of the high Alps. At Paris, the pendulum made 86,400 oscillations per solar day; at Paris the gravity constant g_0 is 980·94. At Chamonix the number of oscillations per day was diminished by 45, at the Observatory by 70; the theoretical value of g_1 at Chamonix is 980·3, the pendulum observations yielded $g_1 = 979·63$. At the Vallot Observatory g_2 should be 979·20; the pendulum indicated $g_2 = 979·08$. On the summit of Mont Blanc, assuming the height 4,810 m. to be correct, the constant should have the value $g_3 = 979·065$; the value deduced by extrapolation from the pendulum observations was $g_3 = 978·83$. Thus, all the gravity values found were too small; the chronometers, moreover, lost 30 seconds per day in the Observatory. These discrepancies are difficult to explain. The only previous Mont Blanc observations available are those obtained by Hansky in 1898 in the old Janssen Observatory.

Superposing Alternating Currents on Direct Currents in Electrolysis.

When alternating currents are superposed upon direct currents, as is frequently done in the study of polarisation phenomena and of the passivity of metals, the effects can not be predicted simply from graphical considerations. Suppose we have a positive direct current of a certain intensity a and an alternating current of amplitude $\pm b$. If $a = b$, we should, by superposition of the two currents, wipe out the negative phase and obtain an undulating current, varying in intensity between $2a$ and zero. If a is greater than b, the resulting undulating current should always be positive; if a is smaller than b, the resulting current might be negative. But even in metallic conductors matters are not so simple, and in electrolytes decomposition, polarisation and diffusion of the gaseous or liquid products and their chemical affinities will complicate matters. Alternating currents are sometimes said not to call forth electrolysis, because the decomposition of the one phase is supposed to be reversed by the next phase; but that depends upon the factors stated and also upon the frequency. Thus, Günther Schulze observed recently that he could not indeed generate hydrogen and oxygen by electrolysing water or sulphuric acid with currents of 50 cycles and two entirely equal platinum electrodes—unequal electrodes would produce some preferential unidirectional effects. But, when he electrolysed a solution of the sodium metaphosphate $Na\ PO_3$ with aluminium electrodes, he obtained a mixture of hydrogen and oxygen in quantities as if each phase were electrolysing independent of the other; in this latter case the electrolyte attacked the electrodes. Curious effects of the superposition of alternating currents on direct currents, notably a stimulation of the reactions which seem to take place at diminished potentials, have frequently been recorded, but the various investigators do not agree as to the facts and their explanations. In describing some experiments of his own before the Faraday Society recently, Mr. W. R. Cooper, M.A., distinguished between low frequency current of 50 cycles and high-frequency current produced by putting an induction coil and condenser with spark gap in shunt to the direct current. The combination of low-frequency and direct currents did not give rise to noteworthy rectification, nor to a distinct acceleration of the rate of corrosion of a copper plate in copper sulphate. But the electrolysis of sulphuric acid by platinum electrodes was decidedly stimulated, and the hydrogen bubbles liberated were of large size, whilst the oxygen bubbles escaped more easily and remained small. Direct currents of low intensity had a relatively larger effect on the combination than direct currents of high intensity. When high-frequency currents and direct currents were combined, there was little electrolytic decomposition, even with strong currents, until the potential rose above 2 volts, whilst with low-frequency currents 0·25 volt had sufficed to call forth electrolysis. Mr. Cooper also noticed a peculiar novel effect. Reducing the current until not more than one or two minute bubbles would be liberated per minute, or cutting the direct current out altogether, and then passing one spark across the gap, he saw that a large bubble would start to form, not at the electrode, but at some distance from it, 3 mm. below the electrode, which might be anode or cathode.

Slip-cone Formation and Material Testing.—In a paper on "Slip-cone Formation as Basis for Material Testing" (*Zeitschrift Verein. Deutsch. Ingenieure*, June 10, pages 566-571) Dr. Ing. F. Riedel submits some considerations which are best explained by one of his novel experiments. He starts from specimens of iron of the shape of a double cone, X-shaped, and compresses these in a furnace which is heated up to 1140 deg. C., the pressure being normal to the two parallel bases; the base angle (slip-cone angle) of this iron is 49 deg. The specimen is flattened out by the compression, but the cone-angle remains constant. When, however, the experiment is made with a similar double cone, not of the correct base angle, but of an angle of 62 deg., the angle does not remain constant, and the specimen is compressed to a more or less cylindrical block showing an equatorial ridge. There is thus a characteristic cone angle. The converse experiment would be to draw the compressed first specimen out on a tension machine and see whether the original double-cone X was re-obtained. As this cannot well be done, Riedel provided an ordinary cylindrical test rod, half way between the ends, with a circular V-groove of the angle of 82 deg., the apex angle corresponding to a base angle of 49 deg.; when the rod was broken on the tension machine the drawn-out ends were found to be of the correct cone shape. Riedel now points out that when a vertical cylindrical block is compressed, the block does not keep its cylindrical shape as it ought to do if the strains were uniform, but it bulges out in barrel fashion. This is usually ascribed to friction between the cylinder bases and the parts of the machine in contact with them. According to Riedel a slip-cone forms on each base which, maintaining its shape, forces the material between the conical surface and the cylindrical surface out laterally, as it is itself forced downward; as long as the two slip-cones, the upper and lower, are not in contact with one another, the stress-strain curve is not hyperbolic. Experimenting with lead, copper, aluminium and iron (hot) he finds that different portions must be distinguished in that curve which becomes hyperbolic at the point corresponding to the contact of the two cones. For these reasons cylinders of equal base differing in height, as well as cylinders of equal height, but different base, do not give the same compression curves, and test results should not be referred to cross-section, the problems being three-dimensional. The considerations suggest that the strength of materials is really higher than is generally assumed; it is well known that structures often bear stresses which theoretically should crush them. Though Riedel considers shear, he does not refer to the studies of the maximum angle of shear by Perry and others; that shear angle is his slip-cone angle with the angle of repose.

LITERATURE.

A Handbook on the Winning and the Utilisation of Peat. By A. Hausding. Translated from the third German edition by Hugh Ryan, D.Sc., Professor of Chemistry in University College, Dublin. London: His Majesty's Stationery Office, 1921. [Price 30*s.* net.]

One of the problems for which science has not found a certain and adequate solution is the economical utilisation of peat. This material is widespread throughout the world, easy of access, for it lies on the surface, and its volume is so great that the amount of combustible matter in the peat bogs exceeds that of all the known coalfields. Scientific men have exerted themselves with only partial success to make available these vast stores of potential energy, awaiting development, and charlatans, it is to be feared, have exploited the legitimate desires of those who have hoped to turn to profitable account the apparently valueless asset they possessed. The slight pecuniary value attaching to peat has operated adversely on its orderly and economical winning. In many places, as in Ireland, for example, where one-seventh of the entire area is covered with peat bog, local hand labour has seized upon the most eligible spots, and without method or system, appropriated the peat best adapted for domestic requirements. Such ill-regulated methods may be inevitable where the commodity cannot be worked on a commercial basis, but it hinders the establishment of an organised industry and is properly termed by the author "piratical winning." The continuance of the irregular practice places obstacles in the way of future and methodical development by making the drainage of the bog more difficult, defeats plans for the systematic cutting and drying of the peat on a large scale, and renders impossible the subsequent utilisation of the soil for purposes of agriculture or afforestation. The author considers only the winning of peat on a large scale, by processes that alone can assure a profitable industry by promoting manufactures of wide utility. The view is limited to German practice of German methods and these have varied according to the demand for coal, whose cost of mining and transport to any particular locality will determine the possibility of working peat bogs commercially and profitably, as a source of fuel. Lignite and brown coal further affect the peat trade injuriously, for these cheaply-mined substances can be pressed into briquettes, and being clean to the touch and convenient to handle, find a ready sale for domestic purposes. In the effort to compete with these briquettes, the peat manufacture or preparation appears to have taken a retrograde step. It was a mistake to attempt to derive from peat an article similar in appearance and with no greater moisture content than brown coal, and the proper and most economical way of handling peat has been recognised and followed only within a quite recent period. The briquette formed from brown coal, containing about 55 per cent. of water was formed mainly under heavy pressure, with the addition of tar or some such adhesive, and it was too readily inferred by those of little experience, that peat being a substance of similar character could by being treated in the same manner, be made to yield as valuable a fuel at a lower price. But this was to overlook the fact that peat might contain as much as 90 per cent. of water, and was much less adapted for pressing, since it required heavy and expensive machinery in drying, the cost of which would prevent peat competing commercially with pressed coal.

The use of artificial heat in drying peat is to court commercial failure. With an article of such small economic value the treatment must be of the simplest, and a brighter outlook for the use of peat at least as a fuel, followed the recognition that the condensation of the loose spongy fibrous raw material could be best effected, not by employing great mechanical force or powerful presses, but by kneading and intimately mixing by hand the half-decomposed fibrous particles with the humified bituminous constitutents, and allowing the dense, pulpy mass to dry and to contract naturally as the water evaporated. Hand-made, air-dried peat is the cheapest form in which it can be prepared, and being useful for domestic and many industrial

purposes has supported a small trade. But with the rise in wages, the small profit derivable dwindled to vanishing point, and it was evident that commercial success could be obtained only by handling very large masses, extending over considerable areas. Hence has followed the introduction of simple machinery for tearing, separating and disintegrating the mass, from which roots of trees and other heterogeneous materials have been removed.

The tendency has been therefore to improve the mixing and kneading machines, adding dredges and sod spreaders, with other devices for quicker handling and for accelerating drying. Such machines and contrivances are described and the evolution of the peat industry very clearly traced. But even under favourable circumstances, hand peat remains a very loose, felty, mossy mass, easily crumbling and readily absorbing moisture. It is this feature of the great water content, and of the difficulty of reducing it within moderate limits, that constitutes the great obstacle to the winning and utilisation of peat. In embarking in this industry the fact must ever be remembered, that it is necessary to raise from the peat bog and to bring to the working and drying grounds eight times the weight of the peat fuel capable of being utilised. That is, in every 800 kg. of raw peat 720 kg. of water are to be removed by evaporation. Hand-made peat is subject to the additional drawback that it easily crumbles by handling and transport, and consequently another 20 per cent. to 25 per cent. of the dried peat, won with difficulty in a damp climate, where the number of working days is limited to less than 100 in the year, is made unfit for fuel.

If peat is to possess any economic value and to be regarded as an article of commerce, machinery must be employed, but each expense incurred must be warranted by the increased value of the output in proportion. There is no difficulty in obtaining a substance that can be dehydrated, dried, have its fibres split up or removed, and worked up into any convenient form. By well-known appliances such a result is technically possible, but from the commercial standpoint it may not be feasible, for the cost of production may be appreciably more than the value of the product. The peat industry has suffered severely from the application of technical methods that worked admirably, accomplishing all that the inventor proposed, but spelt bankruptcy to the company that worked these ingenious patents.

How small a margin the peat miner has at his disposal will be understood from the statement, that the erection of covered stands under which the peat might be well and quickly dried, have not always proved a commercial success, the increase in expense proving too great for the market value of the peat. Machines, however, are a necessity in the process of kneading and forming the crude peat, but the operation is carried out very thoroughly. Chopping and cutting by knives, revolving in suitable apparatus, are substituted for the bare feet of the peasants, which in many parts of Europe serve as the only means of kneading and macerating the crude peat. In some cases it is said pressure to squeeze out the water is employed, but with doubtful success, and the use of the term "press" is scarcely warranted. For a drying press, as it is called, consists of a beam with a board over it, weighted with stones or bricks, between which the sods are placed in layers of 10 to 15, piled over one another on their flat sides.

When well carried out by any of the processes here described, and the differences in operation are but slight, machine-made peat is found to have few of the defects of hand peat, for the increase of density, the main object of judicious preparation, is accompanied by a decided decrease in the water-absorbing properties. It is asserted that the sods have acquired such a closeness of texture, that they can hardly be broken by the hand, and when cut with a saw a smooth section with a waxy lustre is shown. It neither soils the hand nor crumbles by handling, and can be regarded as one of the cleanest of fuels for household purposes. The carbon content of ordinary cut peat 42·5 is increased in the machine air-dry peat to 48 per cent., and while the density of the former varies from 0·25 to 0·80, the density of the latter rises from 0·80 to 1·20, the ash being reduced from 5 per cent. to 2 per cent. The calorific power by unit volume is, of course, largely increased; in the most favourable cases the thermal units rise from 3,160 to 5,316 calories. The cost of production is very carefully considered by the author, but with the rise of wages since the war, and the depreciation in the value of the mark, it is impossible to draw any useful comparison.

Peat carbonisation offers wide opportunities to ingenuity and has proved a fruitful field to the company promoter, working a variety of patents on a commercial scale, but the author's experience is that these schemes, often technically sound, have had but a short life as commercial propositions. The proposed methods and apparatus are described with some fullness, apparently more for warning the credulous than to serve as guides for imitation or repetition. Peat charcoal, it is admitted, can be made more cheaply than wood charcoal, and has a heating effect little inferior to that of coke. The amount of ash is larger than with wood, and if the products of carbonisation are to be used for smelting purposes, it is desirable to select a peat poor in ash, since the amount of contained sulphur and phosphor may cause trouble. In practice, it is generally found desirable to use a mixture of wood and peat charcoal, in order to keep down the amount of ash.

A more hopeful outlook for the solution of the peat problem is offered by the processes of gasification, for the manufacture of gas for power purposes. The gas is proved to be as efficient as can be obtained from brown coal and gives no more inconvenience in its use. That the process is likely to be commercially satisfactory is due to the fact that peat containing 40 per cent. to 50 per cent. of moisture can be used with good results in these gasifiers, and there is no necessity, as in the case of ordinary peat furnaces, to use peat as air-dry as possible.

It may be recalled here that, previous to the recent disturbances in Ireland, an installation for utilising peat in gas-producer plant was erected at Portadown, and, favoured by local circumstances which made peat cheap and coal dear, gave very satisfactory results. In that case, owing to the smallness of the plant, no attempt was made to recover the by-products, of which the most valuable is ammonium sulphate. The value of these in various forms is apparently greater on paper than in realisation, and is useful as an additional bait to the hesitating investor. The author does not mention the Portadown experiment, but describes that on the Schweger Moor, where the Frank and Caro process was adopted for producing a peat gas for illuminating purposes with the recovery of ammonia.

The experiment was conducted on a fairly large scale, the required power being generated in a 3,000-h.p. central electric power station. At the time of installation, this scheme was hailed as the long-desired complete solution of the peat problem, even in the opinion of experts. But the author cautiously states, "that the hopes for the commercial success of the experiment have not as yet been fulfilled." It adds another to the long list of deferred hopes that the history of the peat industry has to record. The reason for this failure is not known, and many possible grounds are suggested, but the conditions after the war may be different to those that obtained earlier. The value of ammonia may be increased, the demand for coal may be greater and the price higher, factors that make for the increased economic value of peat. The author who ever recommends prudence and caution in embarking on peat utilisation schemes, warning the hopeful that swampy peat bogs will never prove gold mines, would probably agree with those in this country who are of opinion that the most economical use to be made of this widely spread combustible, is to convert it into gaseous fuel in suitable gas producers. In no perfunctory spirit, grateful acknowledgment should be made to the translator, Dr. Hugh Ryan, who, denied the advantage of any possible reference to the author, has provided an excellent translation. The corrections to the original, where necessary, show the care with which the work has been effected.

Steam Turbines. By WM. J. GOUDIE, D.Sc. James Watt, Professor of "The Theory and Practice of Heat Engines" in the University of Glasgow. London Longmans, Green and Co., 1922. [Price 30*s.* net.]

BOTH the theory and practice of steam turbine engineering have undergone remarkable developments during the past few years. On the theoretical side we have had the recognition of the importance of supersaturation, and of the unreliability of the steam tables constructed on the basis of empirical formulas, devised to represent the errors of German experiments on the specific volume of steam, and of German empirical extrapolations of observations on the total and specific heats of superheated steam. Even those who are indisposed to discard their former idols and to accept as adequate the simple and consistent formulas devised by Callendar to represent the properties of steam over the useful range, now admit that Callendar was quite right in maintaining that steam tables to be satisfactory must be self-consistent; and whilst some of them seem still inclined to rely on purely empirical formulas, with no rational or physical basis, they now at least take care that these formulas are not, as was formerly the case, self-contradictory. In the meantime it is of interest to note that further experiments have shown that Callendar's formulas have turned out to be valid for higher pressure and temperatures than their author ventured to hope when his tables were first published in 1915. This might, perhaps, have been anticipated from the isothermal curves for the superheated vapour of CO_2 determined by Andrews. These curves can be represented very fairly by hyperbolas up to within quite a small distance from the critical point. No doubt a discrepancy would be found at somewhat lower temperatures within the supersaturated field, and it is conceivable that at high pressures the volume of supersaturated steam, as met with in turbine practice, may be somewhat smaller than the value deduced from Callendar's equations. Owing to a lack of enterprise on the part of the directors of the laboratories at our technical schools no experimental information on this head is at present available, although it would seem that the apparatus required outside of the ordinary laboratory equipment should be neither expensive nor complicated. For some inexplicable reason, however, repetitions of old experiments, with but minor variations from the originals, seem more popular at these institutions than the task of breaking new ground.

On the practical side the new developments have been equally striking. In the first decade of this century the standard speed for a turbine, rated at 3,000 kw., was 750 r.p.m. Nowadays we have turbines rated at 15,000 kw. and running at 3,000 r.p.m. The extraordinary increase in the output associated with stated speeds of rotation has involved the solution of some very difficult problems. The designer has had to steer on the one hand between the Scylla of excessive centrifugal stresses and the Charybdis of restricted steamways at the exhaust end and consequent "excessive leaving losses." These new developments are very adequately dealt with in the new edition of Professor W. J. Goudie's treatise on "Steam Turbines," which has just been issued by Messrs. Longmans, Green and Co., at the price of 30*s.* net. The first edition of the book was issued in 1917 and was sold out in little over two years. This fact is in itself sufficient to show that the treatise was found of great utility, but the new developments which were but faintly foreshadowed when the first edition was issued, have made it necessary to rewrite a large proportion of the original matter. At the same time many additions have been made, so that the text now extends over 804 pages as compared with 519 pages in the first edition. The illustrations number 329 and include a number of folding plates reproduced from working drawings. A pocket in the cover contains four large scale steam charts, based on Callendar's tables and equations. A very valuable feature, especially to the private student, are the very numerous worked-out examples. The first 160 pages of the volume are mainly descriptive

and show excellent examples of recent turbine practice. The properties of steam are next discussed, following which come chapters on nozzles and blading. The stresses on discs and the critical speed of rotors form the subject of the next chapter, which is followed by one on mechanical-reduction gears, the adoption of which has entirely revolutionised marine steam turbine practice. Mechanical losses form the subject of chapter XII. The title is not entirely satisfactory, since it is no doubt rather a strain of language to class leakage losses under the heading. Parasitic losses would, from the philological standpoint, be perhaps more satisfactory, yet the term mechanical losses can be justified, as it is these parasitic losses which correspond to the mechanical losses in a reciprocating engine, and just as the indicated horse-power of the latter exceeds the shaft horse-power by the sum of the mechanical losses, so does the indicated output of a steam turbine exceed that of the shaft output by the sum of the leakage losses and friction losses. We note in this chapter that the author retains the old formula for the centrifugal pressure head of a water-sealed gland. This ignores the fact that the average angular velocity of the rotating mass of fluid is less than that of the impeller, and hence the actual effective head is somewhat less than the theoretical. So far as we know, the necessity of this correction, though well known to practitioners, has not yet been noted in our textbooks. Some useful data as to the steam consumptions now guaranteed are given in the next chapter. The author also includes the estimates as to future possibilities put forward by Sir Dugald Clerk in his James Forrest lecture of 1920. According to these figures a steam rate of 8½ lb. per kilowatt hour is anticipated with a turbine of 100,000 kw. rated capacity supplied with steam at 450 lb. per square inch (gauge) and at a temperature of 750 deg. Fahr., the vacuum being 29 in. Assuming a generator efficiency of 96 per cent., the foregoing consumption corresponds to a thermal efficiency at the shaft of nearly 32 per cent., and the net heat supply, even in the absence of intermediate feed heating, would be under 8,000 B.Th.U. per shaft horse-power hour. This is rather a better figure than most builders of large gas engines are as yet prepared to guarantee. Of course, it must be borne in mind that the figures for the turbine are an estimate and have yet to be substantiated in actual practice. But the matter is of interest in showing how steadily the gap between the thermal efficiency of the steam turbine and the large gas engine is being narrowed. Professor Goudie's new edition is by far the most complete and up-to-date treatise on the steam turbine which we have yet encountered, and will undoubtedly prove as popular as its predecessor.

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Air Ministry. Report on Benz Aero Engines (Bz 3bO (195 h.p.) and Bz 3bV. (210 h.p.). London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 6s. 2½d. post free.]

Rubber Manufacture. The Cultivation, Chemistry, Testing and Manufacture of Rubber. With Sections on Reclamation of Rubber and the Manufacture of Rubber Substitutes. By H. E. Simmons. London: The Library Press, Limited. [Price 25s. net.]

Aeronautical Research. Committee. Reports and Memoranda. No. 762. Lift and Drag of BE2E with R.A.F. 14 Wings. Comparison of Full Scale and Model Results. By the Aerodynamics Staff of the Royal Aircraft Establishment. [Price 4½d. post free.] No. 766. *On the Free Transverse Vibrations of Aircrew Blades.* By R. V. Southwell and Barbara S. Gough. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 3½d. post free.]

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Happy India; as it might be if guided by Modern Science. By Arnold Lupton. London: George Allen and Unwin, Limited. [Price 6s. net.]

The Design and Construction of Dams; including Masonry, Earth, Rock-Fill, Timber and Steel Structures and the Principle Types of Movable Dams. By Edward Wegmann, C.E., M.Am.Soc.C.E. Seventh edition, revised and enlarged. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 50s. net.]

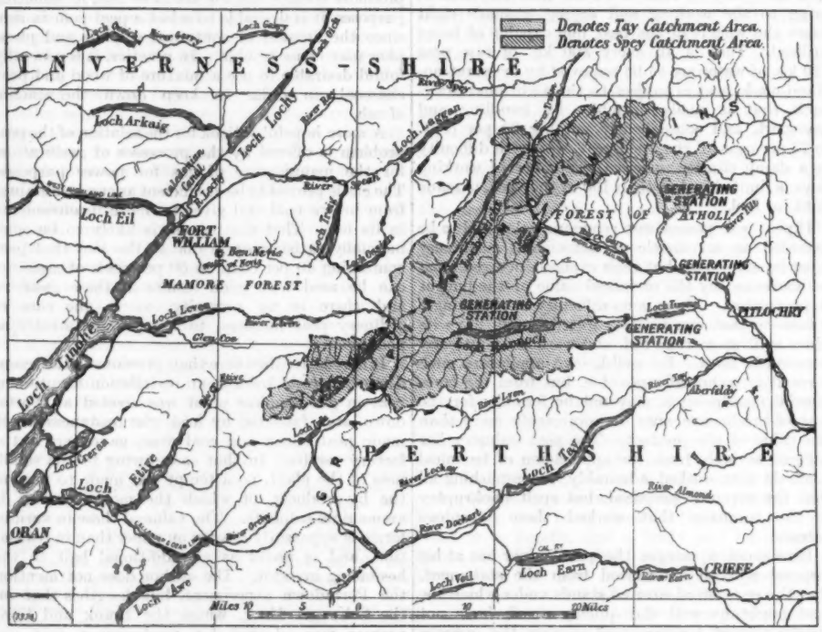
THE GRAMPIANS WATER POWER SCHEME.

The area of supply of the Grampians hydroelectric scheme is intended to be the counties of Perth, Kinross and Forfar, and certain parts of the counties of Inverness, Argyll and Stirling. Authority is sought for 35 intended "works." The proposed arrangement of these is somewhat complicated, but the major lines of the scheme may be indicated as follows: It is intended to develop the water power available from the rainfall on about 418 sq. miles of catchment area, of which 344 sq. miles drain to the River Tay and 74 sq. miles to the River Spey. The salmon fishing interest is of high importance in both cases, but the promoters have succeeded in adjusting protective provisions to the satisfaction of the two District Fishery Boards. The catchment area, comprising Lochs Ericht and Rannoch with their feeders, together with the head waters of the River Garry, Edendon Water, Bruar Water, and the Rivers Tilt, Truim and Tromie (the two last-named being Spey tributaries), is shown stippled on the map annexed; the average annual rainfall over the whole is believed to be about 55 in.

The main feature of the scheme is the conversion of Loch Ericht, by the construction of dams at both ends, into a storage reservoir, for which purpose this large loch, about 14 miles long, is admirably adapted. It is proposed to obtain a range of water level of about 58 ft. (between 1,190 ft. and 1,132 ft. above Ordnance datum, the present water level being about 1,153 ft. above Ordnance datum). This range gives a capacity of nearly 13,000,000,000 cub. ft. Three smaller reservoirs (Loch Garry, Loch an Duin and Loch an t'Seilich) are comprised in the complete Loch Ericht section of the scheme. Unfortunately the natural catchment area of Loch Ericht is not in suitable relation to its storage potentialities, but the promoters propose to correct to some extent the disproportion by diverting into the extended loch, by means of a number of catch-water conduits and tunnels, the head waters of the River Garry, Edendon Water, and the Rivers Truim and Tromie. In this way the 53 sq. miles of natural catchment area of Loch Ericht will be increased to 185 sq. miles. A pressure tunnel is proposed to be driven from the lower end of Loch Ericht to a point on the steep hillside overlooking a suitable site for a power-house intended to be constructed on the shore of Loch Rannoch (proposed top water level 672 ft. above Ordnance datum). The average available fall will be about 450 ft., and it is anticipated that about 26,900 h.p. will be developed.

By means of a dam at Kinloch Rannoch, Loch Rannoch is also to be converted into a storage reservoir. In this case the range of water level will only be 8 ft., giving a capacity of about 1,600,000,000 cub. ft. A comparatively small supplementary reservoir is to be formed by the construction of a dam across the River Tummel (which issues from Loch Rannoch) about 4 miles below Kinloch Rannoch. From this latter dam a conduit, nearly 3 miles long, will be led to feed the lines of pipes to turbines contained in a second power-house situated on the south bank of the River Tummel. Here the Loch Ericht water, after discharge through the turbines in the first power-house, and augmented by the yield of 201 sq. miles of additional catchment area draining to Loch Rannoch and the River Tummel (bringing the total up to 386 sq. miles) has a further fall of about 160 ft., and about 17,400 h.p. is expected to be obtained. The works above described are the main source of power which it is proposed to develop, together constituting one stage of the scheme, the two power-houses being designed to work in reciprocal activity. The power-house on the Tummel is proposed to be "double" so that in times of heavy flood the outlet from Loch Ericht may be closed. In this way the abundant capacity of the Loch Ericht reservoir will be used to compensate for the deficiency of the Loch Rannoch reservoir.

The remaining portion of the scheme contemplates the utilisation of the yield of about 32 sq. miles of catchment area draining to the Bruar Water and the River Tilt. By means of conduits, partly in open cut and partly in tunnel, the head waters are to be conveyed to an intended reservoir on Allt Mhaire embracing Loch Mhaire. The head waters so controlled are intended to be developed, firstly, through a fall of over 500 ft. to a power-house situated on the east bank of the Bruar Water, where 4,700 h.p. will be obtained. Below this power-house the discharge from the turbines, together with additional Bruar water originating below the level of interception of the head waters, will be impounded and led through a pressure tunnel to a point overlooking the River Garry about 2 miles above Blair Atholl. Here a further fall of about 800 ft. will be available and at a power-house proposed to be constructed on the north bank of the River Garry it is hoped to develop about 7,500 h.p. A total of about 56,500 h.p. will thus be made available at the four power houses contemplated under the complete scheme.



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The proposals of the promoters were closely scrutinised by a Committee of the House of Commons. The view of the committee appeared to be that the scheme was meritorious but speculative, and in these circumstances a good deal of exception has been taken to the intimation of the Trade Facilities Act Committee that, subject to the approval of the Electricity Commissioners, they will be prepared to recommend a State guarantee of both capital and interest of the debenture issue of the company equal in amount to the ordinary share capital of the company. The first stage of the scheme (the Loch Ericht and Loch Rannoch portion) was estimated to cost 2,600,000*l*. To enable this expenditure to be met a share capital of 1,750,000*l*. was approved; authority was also conceded to borrow 875,000*l*. without the consent of the Electricity Commissioners, and with the consent of the Commissioners a further 875,000*l*. may be borrowed. The engineers of the Grampian scheme are Messrs Mott, Hay and Anderson, Westminster, and Signor Angelo Omodeo.

DEVELOPMENT AND MANUFACTURE OF HIGH TENSILE BRASS AND BRONZE.*

By O. SMALLEY, M.Inst.M. (Newcastle-on-Tyne).

IT is intended in this paper to treat synthetically the development of complex high-strength brasses and to consider the principal problems of manufacture. In the past these alloys were termed "manganese bronzes," and in specific cases prefixed by either the inventor's or a trade name. This no doubt arose from their complex nature and costly practical evolution. At the same time it is a misnomer and surrounds them with an air of mystery which retards rather than advances their progress.

The base of practically all the so-called "manganese bronzes" is brass, and they do not derive their special virtues from manganese. The Institute of Metals has suggested the name "brass," preceded by the name of the special elements introduced, *e.g.*, the presence of aluminium would identify it as "aluminium brass," "manganese" as "manganese brass," if both these elements are present as "aluminium-manganese brass," and so on. This is a step in the right direction, and the recommended appellation will be adopted throughout this paper.

To understand the function of the numerous special elements commonly introduced, viz., aluminium, manganese, iron, nickel, &c., a working knowledge of the constitutional diagram of the copper-zinc series of alloys is essential. This diagram is generally avoided by the foundryman and engineer on account of its formidable appearance and the adoption of Greek terms. Yet it presents a fund of information which may be readily interpreted by anyone interested. Fig. 1 shows both the constitutional diagram and the physical properties of the pure copper-zinc series of alloys in the "cast" state.

Considering the interpretation of the constitutional diagram only, *i.e.*, the thin black lines, from lines A B C D E the melting point of any brass may be obtained; increase the temperature by 10 per cent. to 12 per cent., and a good idea of the correct casting temperature is obtained. Line A F M N O Q gives the temperature of complete solidification. The difference of temperature between these two lines is a measure of the range of temperature through which any brass cools during solidification. Area A F H G O, including all brasses to 37·2 per cent. zinc, shows that those containing up to 30 per cent. zinc will proceed uninterrupted by any subsequent physical changes after solidification, *i.e.*, they will consist of a single homogeneous solid solution of copper and zinc at all temperatures. This solid solution is termed "alpha" brass, and for all practical purposes is unaffected by the rate of cooling.

Exceeding 30 per cent. zinc, another constituent appears alongside with the "alpha," and for want of a better name is termed the "beta" constituent. As the zinc content increases, the greater the quantity of the "beta" and the less the quantity of "alpha," and between 46·7 per cent. and 49·7 per cent. zinc, none of the "alpha" constituent exists, but only the "beta."

In the 30 per cent. to 37·2 per cent. zinc series of brasses the line F H G marks where they pass from a region in which both the "alpha" and "beta" phases can exist side by side, into the main "alpha" zone, where this constituent alone is stable. The "beta" constituent must then exist in a metastable state, and, if normally cooled, changes into the "alpha" phase on the alloy passing through the temperature represented by that point on line F H G. If, now, a brass of this series is quenched in the "alpha beta" area, F H I M, and the rate of cooling is such as not to permit the natural change from the "alpha beta" to "alpha," then a duplex structure will be formed, and the brass will be hardened to an amount determined by the percentage of the "beta" constituent present.

This point has been somewhat elaborated to demonstrate that brasses containing between 30 per cent. to 37·2 per cent. zinc are affected by heat treatment, and though not of practical importance, so far as improved mechanical properties are concerned, an understanding of these physical changes explains many of the defects common to these brasses. A further feature of this series is that they be worked either hot or cold. Exceeding 37·2 per cent. and up to 49·7 per cent. Zn a complex state of affairs exists, and the "beta" constituent remains stable at all temperatures.

The physical changes shown to take place after solidification by region F M N C U G are not strictly correct, and are subject to alteration of academic rather than practical importance. Brasses containing 37·2 per cent. to 46·7 per cent. Zn, being possibly the most important series of the Cu-Zn alloys, form the basis of all high tenacity brasses, and consist of both the "alpha" and "beta" constituents. If quenched from high temperatures—*i.e.*, temperatures above the line I M—the change from "beta" to the "alpha beta" is suppressed. Such brasses, then, may have an all "beta" structure—*i.e.*, their physical properties may conform in many respects to brasses containing between 46·7 per cent. and 49·7 per cent. Zn. It is also evident that the nearer the zinc content to the limit 46·7 per cent. the lower the temperature necessary to effect this physical change.

The next group of alloys to be considered are those containing 46·7 per cent. to 49·7 per cent. Zn. These have little commercial value. Their constitution is ambiguous. According to the accompanying diagram, the region of true stability of "beta" brasses is confined to temperatures above 470 deg. C., and whilst it must be admitted, by the inclusion of line HIJK, showing that some critical change occurs at these temperatures, which the author has never been able to demonstrate by heat treatment alone, that they mark the transition of the "beta" constituent into its component parts, "alpha" and "gamma," as is commonly alleged. That some critical change does occur at or about 620 deg. C. is supported by: (1) This marks the true limiting forging temperature of practically all the "beta" brasses; (2) it indicates the temperature of incipient heat fragility; (3) it is the correct annealing temperature for practically all pure brasses.

It is of interest to note at this stage that it is brasses which enter into region M I J N—*i.e.*, the "beta" brasses, which specially lend themselves to working hot, whilst those consisting of only the "alpha" constituent are peculiarly suitable for working cold.

Exceeding 49·7 per cent. Zn, a new constituent, "gamma," makes its appearance. This is a hard, brittle alloy, and its inception in the most minute traces renders brass extremely brittle and useless as a material of construction. So brittle is the "gamma" phase that an alloy containing 60 per cent. Zn—*i.e.*, all "gamma,"—may be crumbled between the fingers.

The thick black lines, Fig. 1, show the physical properties of pure brass, correctly cast in chill moulds; and in Fig. 2, the physical properties after mechanical and thermal treatment, such as to remove completely casting structure, internal strain and heterogeneity. In short, Fig. 1 may be used as a standard of the physical properties of brass castings. Fig. 2 of rolled, extruded and forged brass when correctly annealed.

Fig.1. CONSTITUTIONAL DIAGRAM OF PHYSICAL PROPERTIES OF Cu-Zn ALLOYS "AS CAST."

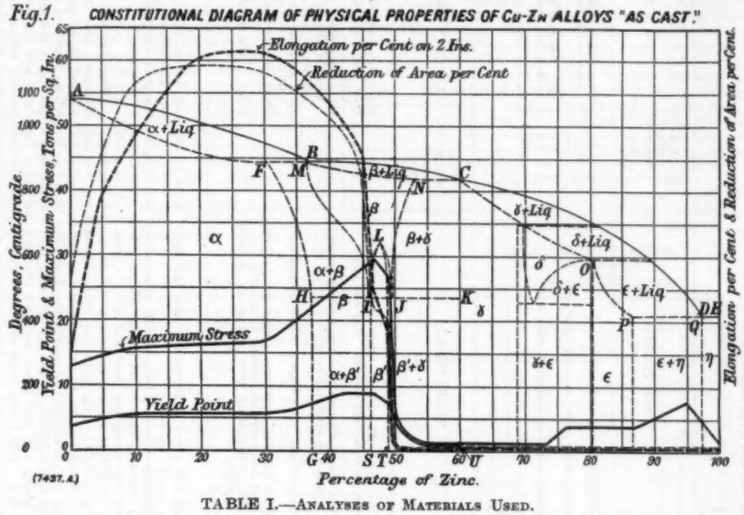


Fig.2. MECHANICAL PROPERTIES OF Cu-Zn ALLOYS AFTER TREATMENT.

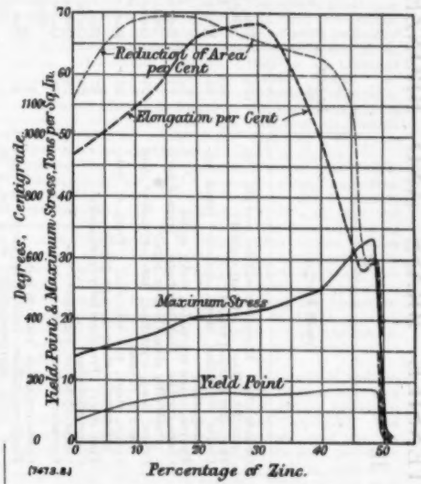


TABLE I.—ANALYSES OF MATERIALS USED.

Material.	Zn.	Cu.	Pb.	Fe.	Sl.	Al.	Sn.	Cd.	O.	P.	Co.	Ni.	As.	Mn.
Zinc (Crescent brand) ..	99·99	Nil	Tr.	Tr.	Tr.	—	—	Tr.	—	—	—	—	—	—
Zinc (Crown brand) ..	98·58	0·03	1·13	0·14	Tr.	—	—	0·12	—	—	—	—	—	—
Copper (Wallaroo brand)	—	99·81	Tr.	Tr.	—	—	—	—	0·19	—	—	Nil	—	—
Aluminium	—	Tr.	—	0·40	0·09	99·51	—	—	—	—	—	—	—	—
Tin	Nil	Nil	0·20	Nil	—	Nil	99·7	—	—	—	—	—	0·10	—
Ferro-zinc	94·10	0·29	1·16	4·45	—	—	—	—	—	—	—	—	—	—
Ferro-copper ..	—	90·00	—	10·00	—	—	—	—	—	—	—	—	—	—
Copper-manganese ..	—	72·73	0·09	2·36	0·30	—	—	—	—	0·03	—	—	—	24·35
Cupro-nickel	—	92·58	—	Tr.	—	—	—	—	—	—	—	7·42	—	—
Cupro-cobalt	—	90·00	—	0·20	—	—	—	—	—	—	9·76	0·04	—	—

TABLE Ia.—PHYSICAL PROPERTIES OF PURE BRASS.

Composition. Cu.	Zn.	Condition.	Y.P. Tons per Sq. In.	M.S. Tons per Sq. In.	En. per Cent. on 2 In.	R.A. per Cent.	Alternating Impact No.	Brinell Hardness No.	Sclero-scope Hardness No.
70·0	30·0	As cast	6·50	16·70	58·00	57·00	79	55	15
		As forged and annealed	8·00	21·50	68·00	65·00	85	57	15
59·0	41·0	As cast	8·80	24·90	45·00	49·70	79	90	14
		As forged	9·00	26·00	47·00	62·00	87	90	14
		Forged and annealed, 650 deg. C. for 1 hour	7·00	24·00	49·00	55·00	—	79	12
53·3	46·7	As cast	9·00	29·70	24·00	21·50	34	108	18
		As forged	9·70	32·80	28·00	30·60	49	114	18
		Forged and annealed, 650 deg. C. for 1 hour	7·50	29·10	22·50	31·60	—	108	18
51·2	48·8	As cast	7·20	26·90	19·00	21·50	27	108	18
		As forged	9·20	33·40	37·00	33·50	36	114	18
		Forged and annealed, 650 deg. C. for 1 hour	5·30	29·00	25·00	27·00	—	108	18
50·19	49·81	As cast	6·00	8·80	1·00	1·50	1	108	18
		As forged	2·30	15·80	5·00	5·50	9	117	19

DEVELOPMENT OF HIGH TENACITY BRASS.

In this research constant conditions were maintained throughout, eliminating all variables except the one desired, viz., chemical composition. For this reason virgin metals and specially prepared stock alloys were used, the chemical compositions of which are given in Table I. Two grades of zinc were adopted, owing to the uncertain test-figures previously obtained from castings and forgings made with the lower grades of spelter. Owing to the difficulties of obtaining standard conditions with a sand mould, each casting was made in a 2½ in. sq. chill mould, pouring with exactly 10 per cent.

* Paper read before the Institution of British Foundrymen, Birmingham Conference, 1922.

THE DEVELOPMENT OF HIGH TENSILE BRASS AND BRONZE.

TABLE II.

No.	Actual Composition. Cu.	Zn.	Al.	Mn.	Fe.	Physical Condition.	Y.P. Tons per Sq. In.	M.S. Tons per Sq. In.	E. per Cent. on 2 In.	R.A. per Cent.	Tensile Fracture.	Impact No.	Fracture.	Izod Impact No.	Brinell Hardness No.	Scleroscope Hardness No.
9	69·79	26·67	3·54	Nil	Nil	As cast	13·60	29·30	26·00	27·60	Oblique silky. Elongation uniform over the 2 in. parallel. Trace of inter-crystallinity	101	Fine, stony, semi-vitreous, silky edges	—	104	—
						As forged ..	23·40	37·10	34·00	41·90	Fine, silky oblique, necked	91	Ditto. ditto.	—	143	—
10	69·13	26·32	4·55	—	Trace	As cast	17·6	31·9	8·0	11·7	Coarse crystalline, stony, defective (sand contamination)	33	Mixed crystalline and granular, free from lustre	—	134	32
						As forged ..	20·3	38·6	17·00	20·00	Uneven, coarse crystalline, stony, sound	51	Ditto. ditto.	—	143	34
11	69·42	24·58	5·90	—	—	As cast	28·10	38·00	3·00	1·50	Coarse crystals. Free from lustre. Trace of inter-crystallinity along the 2 in. parallel	13	Very coarse, crystalline, crystal grains free from lustre	—	185	—
						As forged ..	32·50	42·30	6·00	8·40	Coarse, stony, crystalline. Inter-crystalline along the 2 in. parallel	25	Coarse, crystalline, inclined to be lustrous	—	193	—
A.1	59·48	39·52	1·00	—	—	As cast	14·80	32·00	30·00	33·50	Coarse, stony, and accicular. Trace of inter-crystallinity along the 2 in. parallel	46	Fine, stony, vitreous ..	40	114	21
						As forged ..	11·10	31·30	41·00	44·60	Fine, stony. Free from inter-crystallinity ..	67	Fine, stony, semi-amorphous	41	104	18
A.2	58·35	40·11	1·54	—	—	As cast	16·4	35·20	17·00	18·50	Coarse crystalline	23	Coarse crystalline, stony ..	—	129	21
A.3	58·26	38·56	2·18	—	—	As cast	16·000	36·40	16·00	21·50	Coarse crystalline, high lustre	25	Coarse crystalline, stony ..	—	138	22
						As forged ..	11·70	37·40	27·00	33·50	Coarse crystalline, lustre	30	Coarse crystalline, strongly laminated ..	—	143	23
A.4	59·85	37·13	3·02	—	—	As cast	22·30	42·00	18·50	21·50	Coarse crystalline, high red lustre	27	.. ..	—	150	25
						As forged ..	19·00	40·3	24·50	30·60	Highly crystalline. Brilliant red lustre. Presence of slight inter-crystallinity along the 2 in. parallel	41	Fine, stony, inclined to exhibit inter-crystallinity	—	154	23

No. 11 showed 133 crystals per square centimetre as cast and 2,430 when forged.

TABLE III.

Series No.	Composition. Cu.	Zn.	Mn.	Fe.	Sl.	Physical Condition.	Y.P. Tons per Sq. In.	M.S. Tons per Sq. In.	E. per Cent. on 2 In.	R.A. per Cent.	Tensile Fracture.	Alternating Impact No.	Fracture.	Brinell Hardness No.	Scleroscope Hardness No.
M.1	58·95	39·72	1·01	0·24	0·08	As cast	10·1	25·1	51·0	49·7	Fine, stony, semi-cup and cone	59	Fine, silky, slightly vitreous in appearance in the lower half	80	13
						As forged ..	10·1	26·1	47·0	57·0	Fine, stony, silky edges, semi-cup and cone	—	.. ..	—	—
M.2	58·42	39·80	1·48	0·25	0·05	As cast	8·9	26·0	49·0	61·5	.. ..	74	Fine, stony, slightly crystalline	90	14
M.3	58·42	39·25	2·00	0·28	0·05	As cast	9·1	26·9	45·0	52·7	Fine, stony, semi-cup and cone, silky edges	63	As M.2, but more crystalline	90	14

TABLE IV.

Series No.	Composition. Cu.	Zn.	Sn.	Fe.	Physical Condition.	Y.P. Tons per Sq. In.	M.S. Tons per Sq. In.	E. per Cent. on 2 in.	R.A. per Cent.	Tensile Fracture.	Alternating Impact No.	Fracture.	Brinell Hardness No.	Scleroscope Hardness No.
S.1	59·95	39·38	0·47	0·20	As cast	11·0	26·2	44·0	42·0	Fine, stony, silky edges. More or less hackly ..	77	Fine, silky, semi-vitreous	87	13
					As forged	15·6	28·8	38·0	60·0	Fine, granular, silky edges. Cup and cone ..	113	Fine, granular, semi-vitreous in upper half	107	15
S.2	58·90	40·10	1·00	Trace.	As cast	9·6	26·7	32·0	33·5	Fine, stony, silky edges. Trace of crystallinity existing as exhibited by S.3	47	Fine, crystalline, with a slight appearance of the laminated crystals exhibited by S.3	98	15
					As forged	13·6	28·6	38·0	44·6	Fine, granular, silky edges. Semi-cup and cone ..	107	Fine, granular, semi-vitreous in upper half	107	16
S.3	58·82	38·76	2·11	0·31	As cast	11·8	26·1	13·0	15·0	Short, coarsely crystalline, consisting of greyish and stony crystals existing alternately	5	Short, grossly coarse laminated crystals	114	20
S.4	59·17	37·63	2·98	0·22	As cast	16·4	21·25	1·5	3·2	Coarse, alternating grey and stony coloured crystals	1	Short, coarse, laminated crystals ..	136	23

superheat and controlling the temperature of the mould at exactly 130 deg. F. (55 deg. C.).

PHYSICAL PROPERTIES OF PURE BRASS.

In order that complete data should be obtained both regarding the peculiarities of manufacture and mechanical properties, each alloy was made under works conditions. Melting was performed in a 50 or 100 lb. crucible, according to the size of casting, in a natural-draught coke furnace. The method of introducing the various special metals investigated, and the precautions necessary, will be detailed under each distinctive heading. These, by no means arbitrary or exhaustive, represent a practice that has withstood the test of time and can be commended.

Mechanical Treatment.—Where it was desired to investigate in the forged or heat-treated condition, the lower half of the ingot was forged into 1 in. sq. bars. In the case of cold working alloys, a 100-lb. ingot was cast 1·05 in. by 4 in. broad. The lower half was cold rolled in three passes to 0·55 in., annealed at the correct temperature, reduced to 0·45 in., and re-annealed so as to restore to its original "cast" Brinell hardness number before testing.

Physical Tests.—Tensile tests were prepared in accordance with the specification of the Engineering Standards Committee, the area being 0·25 sq. in., and the gauge length 2 in. A permanent set of 0·01 in. is recorded as the yield point (see Table IA).

Hardness.—The Brinell ball-test and the Shore scleroscope were used for this purpose. The former being made with a 10 m/m ball under a pressure of 1,000 kgs., maintained for exactly 30 sec., whilst the latter were made with a soft hammer.

Dynamic Stress Tests.—Both alternating and single-blow impact tests were made where possible. In the former the test-piece used was 4 in. × ½ in. × ½ in. with a ⅛ in. radius groove milled in the centre of one face, at right angles to the principal axis. A steel tup having a total weight of 10 lbs. was allowed to fall from a height of 18½ in. on to the test-piece, the first blow being given on the face opposite to the groove, and, for every succeeding blow, the test-piece rotated through an angle of 180 deg. The blows were delivered at a regular rate of 25 per minute, and the number taken to break completely the test-piece, was recorded as the alternating impact number. The single-blow impact test was made in the Izod machine, using the standard 10 m/m square test-piece, notched 2 m/m deep at an angle of 45 deg., and the striking hammer contacting the test-piece at a distance of 22 m/m above the bottom of the notch.

ALUMINIUM BRASSES.

Manufacture.—The copper was first melted under charcoal, the necessary additions of aluminium made with stick aluminium and the zinc worked in last. The whole was well stirred, introducing a little salt from the bottom of the pot, and allowing to remain in the furnace until the desired temperature had been reached, this usually taking from 5 to 8 minutes. The pot was withdrawn, the temperature measured with a Pt.-Pt.-Rh. thermocouple and cast at the predetermined temperature.

From the point of view of practical utility 1·0, 1·5, 2·0, 3·0, 4·0, 4·5, and 5·8 per cent. of aluminium were

chosen as the most suitable quantities. These were decided upon from a series of exploratory casts, when it was found that 1 per cent. Al equalled approximately 5·6 per cent. Zn in its effect on the general physical properties. For example, a 70 per cent. Cu-26·5 per cent. Zn-3·5 per cent. Al brass possesses the principal features of ordinary Muntz metal; a 70 per cent. Cu-24·2 per cent. Zn-5·8 per cent. Al brass somewhat similar features to a 53/47 i.e., all "beta" brass. Likewise a 59 per cent. Cu-39·67 per cent. Zn-1·33 per cent. Al brass appears to be equivalent to 70 per cent. Cu-24·4 per cent. Zn-5·8 per cent. Al brass or to a 53/47 brass, and so on. These equivalents have also been worked out by Guillet from their structure, and his figure of 6 is in fairly close agreement with the above.

The physical test results obtained from the large scale alloys are embodied in Table II.

Chill Cast.—Prominence is given to the remarkable effect of small quantities of aluminium in increasing the yield point and the strength of both 70/30 and 59/41 brass, which is accompanied by a corresponding fall in ductility and shock resisting properties. Thus alloy No. 9 which is structurally equivalent to a 59/41 brass possesses the strength of mild steel and a remarkable resistance to dynamic stress. Above 3·5 per cent. Al the ductility of a 70 per cent. Cu-base alloy rapidly falls, and at 5·8 per cent. Al, when only the "beta" constituent exists, a high strength is obtained but little ductility.

In the 59/41 series, 1·35 per cent. seems to be the rapid strengthening limit of aluminium, although the maximum strength is not reached until 3·0 per cent. has been added. Exceeding this amount the strength steadily falls away, and on the inception of the "gamma" constituent the alloy loses its commercial value.

After forging, alloys 9, 10, and A1, which are essentially "alpha-beta" brasses, show an all-round improvement in the mechanical properties, and possess a wide range of combined strength and ductility. In the ordinary way "alpha-beta" Al brasses do not present any difficulties in working, and may be forged, rolled or extruded as readily as Muntz metal. Their increased hardness, however, demands a relatively greater blow or pressure in working, and readily hardening up cannot be worked down to small sections with the ease of Muntz metal.

All "beta" aluminium brasses suffer from a long period of heat fragility, regardless of their chemical composition. There is, however, no difficulty in working them hot, although the range of temperature permissible is limited. Ordinary "beta" brasses of the Cu-Zn series have a period of heat fragility extending from 315 deg.-455 deg. C.; "beta" brasses of the Cu-Zn-Al series approximately from 226 deg. to 558 deg. C.

In the "beta" alloys under consideration, forging was performed between 700 deg. C and 620 deg. C. They may be worked safely at temperatures above 700 deg. C., but there is great danger in doing so owing to the abnormally rapid crystal growth at such temperatures, which is not readily eliminated by a continuance of the work at lower temperatures. At the best, high tenacity "beta" brasses are brittle alloys, and slight overheating renders them unsafe in use. An instance of this may be cited in the form of a stop valve for a hydraulic compressor, which gave serious trouble in service. These valves were made to the following chemical composition: Cu, 59; Zn, 36·5; Al, 3; Mn, 1·5; and Fe and Pb, less than 0·2. A tensile test showed that it had a strength of 39 tons per square inch, and an elongation of 15 per cent. on 2 in. Alternating impact tests taken from some of the defective valves ranged between 7 to 10 blows, and the Izod 6 ft.-lb. to 10 ft.-lb., figures which are more or less expected from the appearance of the fractures.

An inquiry into the method of manufacture showed forging to have been performed between 800 deg. C. and 720 deg. C., allowing to cool off on the floor. Forging the ingot at 700 deg. C., overcame this difficulty, and the following is the average physical tests obtained from some of the valves subsequently made: Yield-point, 21 tons per square inch; maximum stress, 43 tons per square inch; elongation on 2 in., 26 per cent.; reduction of area, 34 per cent.; alternating impact number, 48; and Izod, 27 ft.-lb.

Fig. 3 gives some idea of the effect of temperature on the rapidity of crystal growth of aluminium brasses.

MANGANESE BRASS.

Manganese may be introduced by means of an 80 per cent. Mn, ferro-manganese, or 30 per cent. Mn, cupro-manganese. The common objection to the former is its high melting temperature and its association with 5 per cent. to 6 per cent. carbon which renders alloying difficult. The principal trouble arising from the use of Fe-Mn, apart from these difficulties, is the inability to control the chemical composition of the finished alloy and the formation of intensely hard metallic pellets, which pellets not only create serious trouble in machining, but adversely affect the mechanical properties. This latter defect has been encountered in castings made by various foundries, and in every instance a chemical and physical examination proved the trouble to be unalloyed ferro-Mn. The use of cupro-Mn by no means ensures freedom from this defect; it is no uncommon thing to find lumps of undissolved ferro-Mn in cupro-Mn alloys, unless skilfully prepared.

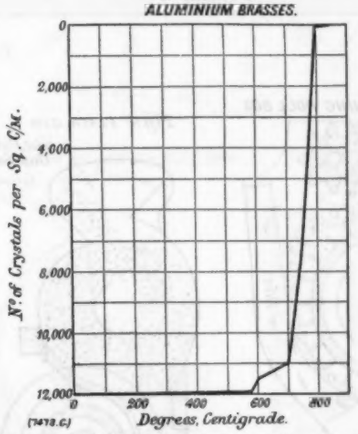
Commercial cupro-Mn is best made, by first melting the Cu under a slag consisting of 1 part broken glass, 1 part fine silica sand, and 1 part borax, stirring in molten ferro-Mn a little at a time. The whole should then be brought to a good temperature, a little phosphor-copper added (0·03 per cent. P. calculated), again well stirred, skimmed and cast. Obviously special care is needed in the preparation of this alloy. If the Cu and ferro-Mn are melted together there is always the danger of some few specks of undissolved ferro-Mn remaining, which are quite sufficient to cause trouble. The use of a protecting flux is necessary, or the melting losses are high, a hard, rich Mn crust forming on top of the melt. Cupro-Mn may be prepared also from pure Mn and Cu or by the aluminium thermit process. The former is costly, the latter unreliable, and there is no advantage from these expensive methods, if due precautions are taken in the alloying of ferro-Mn and Cu.

In the following examples the cupro-Mn of the composition shown in Table I was used throughout. The Cu and cupro-Mn were melted together under charcoal; Zn was then worked in, introducing a little common salt when the desired melting temperature had been reached in the furnace. The casting temperature was controlled pyrometrically. Considered as a Zn replacing element 1·0 per cent. Mn is equivalent to about 0·8 per cent. Zn. Such a comparison, however, is of little value, the function of Mn lying in other directions.

Details of compositions and physical test obtained are embodied in Table III, showing 1·0, 1·5 and 2·0 per cent. to exert very little influence on the tensile test, although both strength and ductility are slightly improved. Owing to the similarity of these three alloys, and as they show no marked variations from the ordinary standard 59/41 brass, forging tests were conducted on alloy M.1 only. This does not call for special comment, and Mn. does not appear to affect the hot working properties. The value of Mn as a deoxidant lies in its ready affinity for oxygen. When introduced in quantities in excess of that necessary to de-oxidise, its ready oxidation is responsible for considerable trouble in casting, and special precautions are necessary in temperature control and method of pouring, or exfolintion of oxide will be encountered, and cause much defective work.

Microstructure.—Under the microscope both M.1 and M.3 appear to possess the structure of ordinary 59/41 brass, although a notable reduction in the size of

Fig.3. SHOWING THE RAPIDITY OF GROWTH OF ALUMINIUM BRASSES.



primary crystal grains is evident, and also indications of a better cohesion between adjacent grains, which suggests Mn to be of value as a toughener. This assumption appears to be substantiated by the impact test figures obtained from alloys M.1, M.2 and M.3.

TIN BRASS.

The chief function of tin in brass is to improve the corrosion-resisting properties. In complex brasses of high ductility 0·7 per cent. is the maximum amount that should be used. In naval brass the limit is 1 per cent.

In a series of exploratory casts it was found that the amount of tin that brass will take into solution in the solid state is determined by the Zn content. In the "alpha" series, the lower the Zn content the greater the quantity of Sn which it can dissolve, *e.g.*, an 80/20 brass will dissolve 5·0 per cent., whilst a 70/30 will scarcely dissolve 1·0 per cent. Of the "alpha-beta" series, the standard 59/41 brass dissolves approximately 1·0 per cent. when sand-cast and 1·2 per cent. chill-cast, whilst as the Zn content increases up to 47 per cent. the solubility rises to a maximum of 1·80 per cent. From these results 0·5, 1·0, 2·0 and 3·0 per cent. tin brasses were made of a 59 per cent. copper base. Conditions of manufacture were those outlined for the aluminium brasses, introducing the Zn and the Sn as such, last.

Physical Test Results.—These are detailed in Table IV.

As Cast.—0·50 per cent. Sn increases the yield point and maximum stress 2·25 tons and 1·3 tons respectively without affecting the elongation, reduction of area, and alternating impact strength. Increasing to 1·0 per cent. hardens, without strengthening, and impairs both the ductility and impact strength. This embrittlement is naturally accentuated by further quantities of Sn, as in alloys S3 and S4, the latter having little strength and being void of ductility.

Forging.—No difficulties were encountered in the forging of alloys S1 and S2, which worked with the ease of ordinary Muntz metal. The test results of alloys S3 and S4 in the "cast" condition were such that they did not justify consideration in the forged or heat treated condition. After forging the yield point of S1 is raised 6·6 tons per square inch, and the maximum stress 2·8 tons per square inch, but the elongation is slightly reduced. The drop in ductility, however, is not of material importance, the alternating impact figure being raised no less than 15 per cent. Whilst the physical properties of the 1 per cent. Sn-brass in the "cast" state are inferior to those of 59/41, they are superior after forging, but it is clearly demonstrated that 1 per cent. is the limit of practical utility

Structure.—There is little perceptible difference in the structure of an "alpha-beta" brass containing 0·5 per cent. Sn and that containing 1 per cent. Exceeding 1 per cent. a brittle Cu-Sn compound, resembling the Cu-Sn compound found in ordinary Sn bronzes, makes its appearance. The effect of this constituent is shown to be similar to the "gamma" compound in ordinary brass.

From these results one cannot regard Sn in the same light as any of the elements previously considered, it being neither a Cu- nor a Zn- replacing element; although, structurally, attempts have been made to consider it as a Zn-replacing element, giving to it a coefficient of equivalence of 2.

(To be continued.)

COTTON-GINNING MACHINERY.

By SOLOMON E. GILLESPIE, Dallas, Tex., Member of the Society.

LONG before the dawn of history the cotton plant was cultivated in various parts of the world, and the earliest records of spinning its fleecy bolls are of such antiquity that it is difficult to obtain satisfactory evidence of its beginning. The name "cotton" itself is of Oriental origin, being derived from the Arabic "koton" or "gootn." India is known as the motherland of cotton, and its earliest history is found in the Rig Veda hymn, composed 15 centuries before the Christian era, which honours the "threads of the loom," and also 3,000 years ago it was used as an ornamental shrub in Egypt.

Alexander the Great acquainted Europe with India, and with that singular plant "vegetable wool," and often referred to "the trees of India bearing wool." Cotton was first imported into England in 1298 A.D., and the manufacture of cotton goods thereafter became one of its greatest industries. In the United States cotton became an early experimental plant, beginning in Virginia in 1600 A.D., and after that date its growth was very rapid. During the war of the American Revolution and immediately thereafter, cotton culture began to receive considerable attention in the Southern States; along the coast, the valuable sea island cotton was raised, and later, in the interior, the upland or green-seed cotton was raised.

Before taking up the ginning of cotton it is well to consider its principal characteristics. There are two general classes or distinctive kinds of cotton grown in the United States, "sea island" and "upland." Sea island cotton does not adhere to the seed, and the lint can easily be pulled off clean, leaving the seed perfectly smooth. The staple varies from 1½ in. to 2½ in. in length, and is of a light creamy silk colour. While strong, it is finer than other kinds, and being about 0·00063 in. in diameter, has a more beautiful lustre.

Upland cotton adheres to the seed, and appears to grow out of them more like wool from a sheep's back. The seed, after being divested of lint as well as possible, still has a woolly appearance, and in a great many varieties a greenish colour and hence upland cotton is referred to as "green-seed" cotton. The staple varies in length from ½ in. to 1¼ in. and its colour ranges from white to a creamy tint. The staple is inferior in strength to the sea island type and coarser, being 0·00076 in. in diameter. The fibres are soft, elastic, moist and pliable, but the natural twist is rather inferior in character to that of sea island cotton, being irregular.

Good commercial cotton must possess certain well-defined external and internal characteristics. The external qualities, which are apparent to the touch or visible to the naked eye are: (*a*) Length of fibre, (*b*) fineness or smallness of diameter, (*c*) evenness and smoothness, (*d*) elasticity, (*e*) tensile strength, (*f*) colour. The internal characteristics, which are discernible by a microscope, are: (*a*) Hollowness, or tubular construction, (*b*) natural twist, due to the collapsed tube, (*c*) corrugated edges, (*d*) moisture.

These characteristics are necessary to constitute a good mature cotton fibre, are essential in effecting the close union of the filaments, and make cotton superior to any other fibre, vegetable or animal. And since the cotton fibre has such a delicate structure and great value, it is necessary that the machinery used in its ginning and cleaning be of such character that the least possible damage will be done to the staple in the process.

The first method to be employed in separating cotton lint from the seed was that of hand picking. The next method, originated in India about 300 B.C., made use of rollers, which when running close together would pull the lint through and leave the seed behind. The roller gin is now used principally for ginning sea island or long-staple cotton and has gone through a long process of development and improvement.

In the United States the great problem that presented itself in the early days of the industry was that of removing the seed from the upland or green-seed cotton. The roller gin in its crudely developed state at that time would handle the sea island cotton to a certain extent, but was not adaptable to and suitable for the upland cotton.

In 1792 Eli Whitney, of Massachusetts, went by boat to Savannah, Georgia, and there developed the first cotton gin, for which a patent was granted him two years later. The original Whitney gin was a hand-power and hand-fed gin, consisting of a horizontal wooden cylinder about 7½ in. in diameter and 2 ft. long, into which wire teeth were driven in rows spaced apart to admit the

* Paper read at the spring meeting, Atlanta, Ga., May 8 to 11, 1922, of the American Society of Mechanical Engineers.

seed cotton, but with the teeth in each row so close together as not to admit seed. The teeth were all inclined the same way, making an angle of 55 deg. to 60 deg. with a tangent at the point of entry. The cylinder had suitable bearings at each end and a hand crank, and above and in front of the cylinder was a hopper to receive the seed cotton, while directly over it was a breastwork or stripping grate consisting of a timber lined with a metal strip having a series of slots through which the rows of teeth could pass, taking the lint cotton but obstructing the seed. The lint was removed from the teeth by means of a cleaner or brush consisting of four sticks with bristles and so constructed that it formed a tangential cylindrical co-acting surface of bristles rotating in an opposite direction to that of the teeth and much faster. It was driven by an endless belt and idler. The gin was not continuous in action, as are the gins of to-day, but had to have its seed dumped from time to time as they accumulated.

Two years later—May 12, 1796—a patent was issued to H. Ogden Holmes of Augusta, Georgia, on a hand-fed and hand-operated gin similar to Whitney's, except that it was continuous in operation, being so constructed that the seed would shed out as fast as they were delinted. This was also the first gin to use metal discs or saws, which were mounted on a square shaft with ends turned down for bearings and the saws separated by space blocks. The brush contained more than four bristle-filled sticks, and was driven in reverse direction to that of the saws and four or five times as fast. This gin would shed the seed continuously as fast as delinted, and the roll of cotton in the roll box would revolve just as it does in the saw gin of to-day.

A little later, larger power-driven gins were employed, Fig. 1, the transmission consisting usually of a large 8-ft. wooden bevel gear mounted on a vertical axis with an extended beam or arm to which a horse or mule was hitched, and a horizontal shaft with a wooden pinion worked in conjunction with the large bevel gear on which shaft a 12-ft. band wheel was mounted and from which the gin was driven at from 200 r.p.m. to 300 r.p.m. by means of a belt. In this system the gin was hand-fed from a platform above. The lint was discharged into a sack suspended beneath a hole in the floor back of the gin, sacking being the first system to be used in handling cotton in the market. Later, however, a lint room was built to receive the lint cotton, which was then carried out of doors in baskets and put into a crude wooden press. This press was of very heavy mill construction, consisting of a single heavy box with discharge doors at the bottom and four large wooden corner struts or tension supports. An elevated platform was built of sufficient height to permit easily placing cotton in the press box from above, just below the overhead sills. The press screw was of wood and 15 in. in diameter with levers fixed to the top end and inclined downward to receive a rope to which a horse or mule was attached. Some presses had roofs over them, while others were left out in the open.

The ginning system was later improved by the addition of a mechanical feeder over the gin and a single lint condenser back of it, and also by the employment of the steam engine for motive power. As the demand for larger output grew, the ginneries were increased to two and three stands and the presses made more modern by the use of a 5-in. steel screw. In some cases the presses were equipped with large steam cylinders, 30 in. to 36 in. in diameter, which operated much more rapidly than the screw press. These small ginneries were commonly known as plantation gins and were a part of the equipment of each large plantation. As the cotton industry grew, however, and the large plantations were superseded by small ones, custom gins came into use, doing away with the plantation gin and compelling inventors to seek better methods of caring for larger capacities at the gins. At first belt carriers were installed back of each battery of gins, which received the lint from each of the single condensers and delivered it to the press box. This crude system, however, was later replaced by a single lint flue receiving the lint cotton direct from the various gin stands—which were in batteries of from two to six stands—and delivering it to a single large lint condenser or bat former, which then delivered it to the press. The lint flues were first constructed of wood, but later sheet iron was used, the diameter being about 18 in. at the smaller end and increasing as gins were added. There is a story in connection with the development of the lint flue that is related by one who is very high in the cotton-gin business, and who was in close touch with its early history and development. The first flue was a wooden box back of the gins leading to the condenser, and in its construction, it was deemed necessary that a wide belt be in the bottom of the flue to assist in carrying the lint cotton that might fall, and to assist further in its travel; but when time came to start the system the wide belt failed to operate, due to the driving mechanism being out of order, and a surprise resulted in the lint cotton being blown on to the condenser by the air produced by the brushes in the gins, which demonstrated that the wide belt was not necessary.

To care further for the large output of cotton at the cotton ginneries, the revolving double-box press was developed. In this press one box acted as a receiving chamber from the condenser and was provided with a tramper or packer which packed 500 lb. of lint cotton in it, after which it was revolved again, bringing the other empty box on to the receiving side while the one filled with cotton was pressed into a bale.

The standard cotton-bale boxes for presses are 27 in. by 54 in. by 10 ft.; the cotton is pressed from the latter dimension down to 36 in. and then six ties are put around it. Before being pressed, however, jute bagging is placed at the top and bottom of the cotton for wrappers. Upon releasing the pressure on the bale it usually expands to 40 in. or 42 in., making a finished bale 27 in. by 54 in. by 40 in. to 42 in. with a density of 12 lb. per cubic foot. A maximum pressure of 10,000 lb. is required in packing a bale of cotton in the receiving chamber and 70,000 lb. to press a standard bale.

Mechanical elevating systems were also developed for use in the large ginneries. The earlier designs were belt carriers, consisting of slats of wood nailed or riveted to two narrow belts, which would drag the seed cotton along from the point where it was fed on by hand to the point of delivery in the feeders. This process, however, required too much human labour, and one comprising a suction fan with vacuum box and belt distributor was next devised. In this system the cotton was sucked from the wagon through a pipe to the vacuum box, in which there was a wire screen to separate the cotton from the air, the cotton then falling on the spiked-belt distributor below, by means of which it was delivered to each gin feeder. The screen area in these vacuum boxes was 1 sq. ft. of ¼-in. mesh screen wire to 14 to 20 saws. The pneumatic elevating system, Fig. 2, was also invented, and consisted of a vacuum chamber or elevated chute over each feeder and gin. This chute consisted of a chamber 12 in. by 53 in. to 60 in. by 6 ft. high with an air and cotton pipe at the top, a screen box attached on the upper back side and a heavy 12-oz. to 16-oz. canvas valve near the centre. This valve was so constructed that when the suction was applied it would close and prevent leakage of air through the valve, causing suction in the telescope pipe in the wagon. This would deliver cotton into the several elevator chutes and then periodically the air would be cut off by means of a valve trip, thus releasing the air suction, and the canvas valves would drop the cotton into the gin feeder. The screen in the pneumatic elevator to separate the cotton from the air is usually light No. 21 gauge, ¼-in. mesh wire, and the screen area is about 1 sq. ft. to 10 saws. The fans used in these two elevating systems are of the steel-plate centrifugal type, varying in size from a 30-in. fan for a two-gin installation to a 45-in. to 50-in. fan for six gins. The peripheral speed of the suction fan-blast wheels varies from 11,000 ft. per minute to 13,000 ft. per minute, which maintains a vacuum of 14 in. to 16 in. of water.

Seed-Cotton Cleaners.—There are many kinds of machines in use for cleaning seed cotton, but the general principle, employed in them all, consists of agitating the cotton on a wire screen of ¼-in. to ½-in. mesh, permitting the dirt, sand, leaf trash and other foreign substances to escape. It is customary in some sections of the country, where climatic conditions interfere with the opening of the cotton boll, to provide a boll-breaking attachment to a cleaner. In some sections where labour is scarce, the seed cotton is not carefully picked from the open bolls but is grabbed; that is cotton, pod and all, are pulled off in a mass. In such cases the cleaning is an important item, because if not carefully handled the cotton will be damaged in the process. Some cleaning machines therefore have a cylinder of saws to separate the seed cotton from the pod or broken

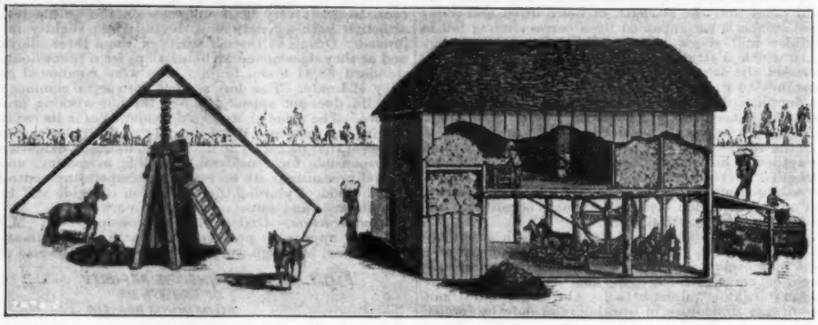


FIG. 1.

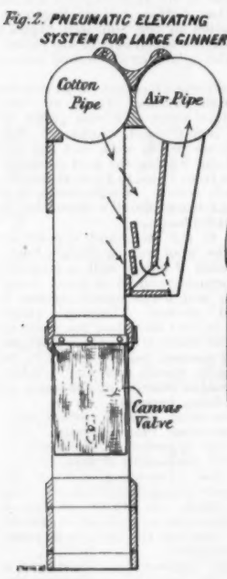


Fig. 2. PNEUMATIC ELEVATING SYSTEM FOR LARGE GINNERY

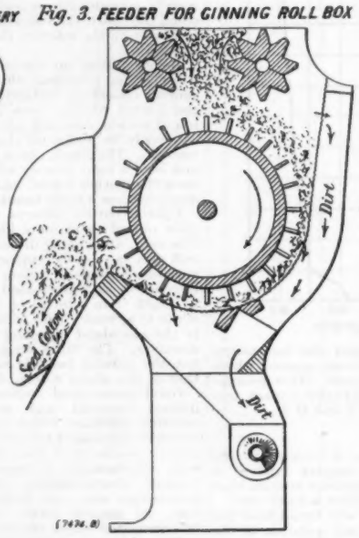


Fig. 3. FEEDER FOR GINNING ROLL BOX

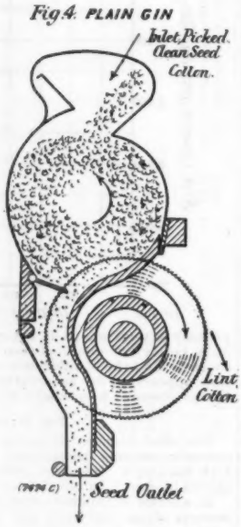


Fig. 4. PLAIN GIN

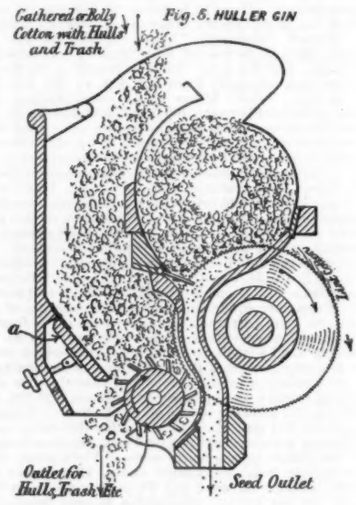


Fig. 5. HULLER GIN

bolls; but this process is best accomplished in the huller gin which will be considered later.

Feeders.—The feeder receives the cotton from the pneumatic elevator or belt distributor above it, and delivers it in a uniform, even amount to the ginning roll box. There are two general types of feeders. The horizontal slatted-belt type that receives the cotton from the belt distributor or pneumatic elevator on a very slow-moving slatted belt and moves it horizontally up to a spiked drum or picker roller 9 in. to 11 in. in diameter, rotating 180 r.p.m. to 200 r.p.m., and provided with a series of No. 8 spikes projecting 1 in. from the surface. These spikes lift the cotton over and throw it down a chute into the ginning roll box. Another general type, Fig. 3, receives the cotton from the elevator chutes or belt distributor on to two fluted rollers 5 in. to 6 in. in diameter rotating toward each other at ¼ r.p.m. to 1 r.p.m. slowly feeding the cotton down where it is taken off by a picker roller similar to the one previously described, and is then whipped around a ¼-in. mesh No. 16 gage wire screen that partly surrounds the picker roller at a distance of about ¼ in. therefore threshing the light leaf trash and sand out of it before delivering it to the ginning roll box. The latest improved feeders are among the most effective cleaning machines in use.

The Seed-Cotton Gin.—The gin stand is the principal machine in the system, as it performs the main work of separating the seed from the lint. There are two general types of saw gins:—(*a*) The plain gin, Fig. 4, that gins only clean seed cotton that is substantially free from bolls and trash and is the original type used; and (*b*) the huller gin, Fig. 5, that separates the seed cotton from the bolls, burrs, leaf trash, dirt and other foreign substances in the front lower roll box, and then carries the seed cotton into the upper roll box where it separates the lint from the seed, thus performing a double ginning operation. The main working parts in both types of gins are the saw cylinder, roll box and a means of removing the lint from the saw teeth after it is separated from the seed.

The Plain Gin.—The standard saw cylinder is made up of a series of 70 to 80 steel circular saws 10 in. to 12 in. in diameter and 0·035 in. thick, mounted on a 2 7/16 in. to 2 7/16 in. mandrel and separated by wood or iron space blocks 0·6835 in. to 0·7396 in. thick and 4½ in. for 10 in. and 6 in. in diameter for 12 in. saws. The 12 in. diameter saw is considered best practice. The saw teeth all incline in the direction of rotation. There are seven teeth per inch, which are punched out and then filed smooth. This punching, however, crystallises the saw steel to a certain extent and often results in defective teeth, with rough edges which are not noticeable to the naked eye but are very distinctly seen with a microscope. Some means should be devised for milling or grinding the teeth instead of punching to insure a perfect smooth tooth free from fracture and crystallisation. The usual practice in the design of the tooth is to make both the front and back edges straight lines. In some cases, however, the front edges have been made straight and the back edges convex resulting in what is known as "hog-back" teeth. The inclination of the teeth edges, Figs. 6 and 7, with a radial line through the point is 36 deg. for the front edge and 57 deg. for the back edge, the two edges making an angle of 21 deg. with each other at the point; this, however, may vary to suit certain working conditions later referred to. The saws rotate with a tooth travel of 1,000 to 1,250 ft. per minute for brush gins and 1,400 ft. to 1,900 ft. per minute for air-blast or pneumatic gins.

Fig. 6. DETAIL OF RIB AND SAW, PLAIN GIN.

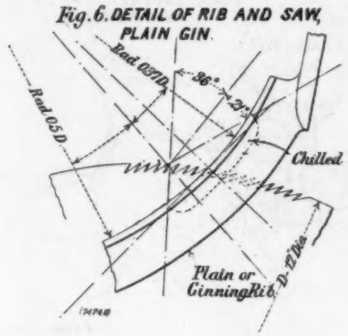
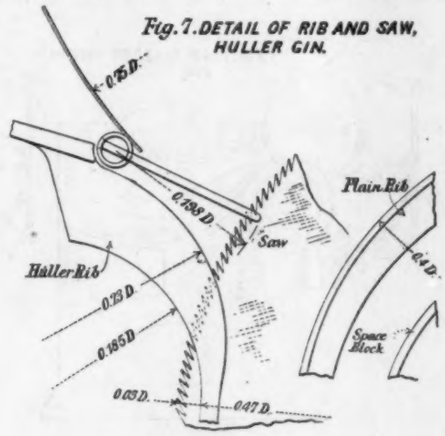


Fig. 7. DETAIL OF RIB AND SAW, HULLER GIN.



The roll box, Fig. 8, consists of a series of ribs between the saws with a half-rib at each end, a back hollow above the ribs, an inlet opening or feed inlet at the top, a cover on the front side with a seed grate attached, and a shield or cover for the exposed portion of the saws below the roll box. In the development of the gin it was found by experiment that the process of ginning worked best by placing the roll box above the saws, thus permitting the roll of cotton to rest on them, Fig. 4; the saw teeth in taking hold of the cotton fibres would cause the whole mass of cotton to revolve in reverse direction, and usually at about a fifth of their velocity, depending upon the quantity of cotton in the roll box and the hardness of the roll.

The cotton roll is theoretically round, Fig. 8, and the same diameter as that of the saws; but due to the necessary working conditions outlined below, its perfect roundness is distorted.

The saws are caused to project up into the roll box from 1 1/16 in. to 1 1/8 in., 1 1/16 in. being considered the best practice. The cotton roll merely rests upon the saws, and the saw teeth, Fig. 4, only project into it. The cotton roll itself when rotating is hollow due to centrifugal force and the cavity in the centre from 25 per cent. to 50 per cent. of its diameter. It is best practice for the roll of cotton in the roll box to be as soft as possible, that is, with as large a cavity as possible, because this prevents the cotton fibres from wedging into the throats of the saw teeth, cutting and knapping the fibres, and also permits the fibres caught by the saw teeth to disentangle from the mass of the roll without breaking off; this precaution is especially necessary when the saw teeth are travelling at a high velocity.

The rib is tangent to the theoretical roll at its lower side; but the curve of the rib cuts up into the theoretical roll with a radius of 37 per cent. of the saw diameter D, and at the upper edge of the rib, from 1¼ in. to 2 in. above the point where the saw teeth pass through there is an offset dropping the working line back tangent to the theoretical roll, to permit the cotton fibres that were pulled between the ribs and not carried away by the saw teeth, Fig. 4, to free themselves from the ribs. The ribs are usually made of cast-iron and at the points where the saw teeth pass between them they are chilled for an inch or so each way, Fig. 6 thus making a hard working surface that exhibits very little wear. The space between the ribs and the point where the teeth pass through is 0·125 in. wide and increases in width in each direction therefrom. The wearing surface of the rib as well as the edges are ground smooth and polished. The lower end of the rib is extended downward beyond the circle of the saw and attached to a rail or bar and the upper end extended just above the offset to attach likewise to a bar or rail, while the inner surface is ground to the curvature (0·37D), of the theoretical roll.

The back hollow begins at the upper end of the rib, tangent to the theoretical roll, and curves inward and upward with a radius of 42 per cent. of the saw diameter D to give the roll a proper density at the ginning point below and also pack it just before reaching the inlet opening at the top. This opening is 28 per cent. of the saw diameter D, and is for the purpose of admitting cotton into the roll box at the top when operating as a plain gin.

The front roll curves are the reverse of those of the rib and back hollow. The front is tangent to the theoretical roll at the intersection of the horizontal centre line with it, and curves outward therefrom toward the top, to allow freedom for the admission of cotton, with a radius of 58 per cent. of the saw diameter, D. It also curves out from the centre line toward the bottom, with a radius of 75 per cent. of the saw diameter D, to allow the roll to loosen so that the ginned and cleaned seed will drop out. Near the bottom of this curve of the front there is a seed grate consisting of a pivoted rod with No. 8 fingers projecting out between the saws and extending ¼ in. inside the saw-tooth curve. By raising the fingers or grates they press up against the bottom of the cotton roll and retard the shedding of the seed, and by lowering them the seed is shed free; if lowered too much, however, the seed is released before the lint is entirely removed, Fig. 4, the ginning being thus regulated. The seed is shed out in the course of its travel from the seed grate to the point where the saw teeth pass between the ribs, the seed that is free from lint dropping out of the roll on the ribs below and escaping to the seed conveyor below. The centre of the roll box is not directly above the centre of the saws because it would cause the ribs below to be too flat and not permit the seed to slide down out of the way, therefore the centre roll box is 25 per cent. of the diameter D in front of the vertical centre line. The exposed portion of the saws below the roll box is covered with a shield to prevent injury to the operator; some roll boxes, however, have fronts that extend down and cover the exposed saws.

The saw teeth in travelling under the cotton roll take

Fig. 9. PROPORTIONS OF HULLER-GIN ROLL BOX

Fig. 8. PROPORTIONS OF PLAIN-GIN ROLL BOX.

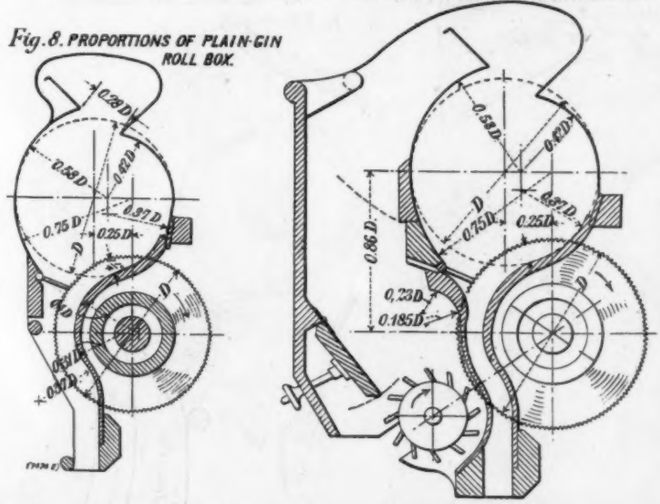
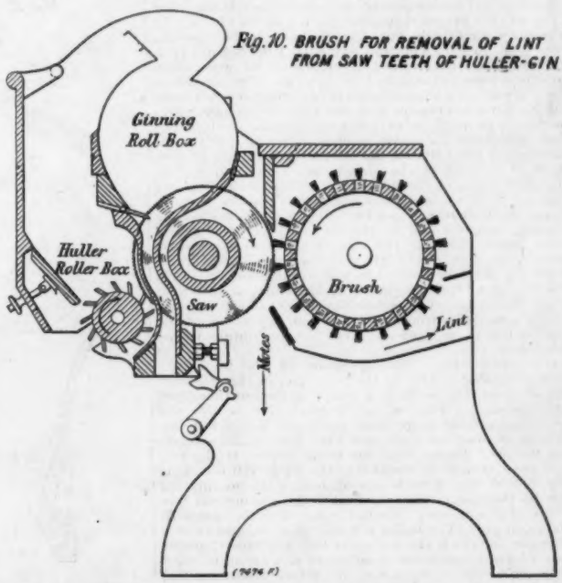


Fig. 10. BRUSH FOR REMOVAL OF LINT FROM SAW TEETH OF HULLER-GIN



hold of some of the fibre and carry it between the ribs, leaving the seed in the roll box to be shed out as above explained. Each saw tooth that is loaded with lint cotton, amounting to from 0·000001418 lb. to 0·000001194 lb. per tooth from brush gins and from 0·000001084 lb. to 0·000000934 lb. per tooth for air-blast or pneumatic gins, being 100 to 160 fibres per tooth based on 29,000,000 fibres per pound, must be unloaded or cleaned before it returns to the roll box again. The removal of the lint from the saw teeth is accomplished by means of a brush, Fig. 10, consisting of a series of $\frac{3}{4}$-in. by 1-in. sticks, usually 22 in number, in which bristles are inserted, usually projecting 1 in. from the stick. These sticks are mounted on a series of drum heads on a shaft $1\frac{1}{16}$ in. to $2\frac{5}{16}$ in. in diameter. The outside diameter of the brush cylinder is usually 15 in. Each brush has four wings 1 in. by 6 in. on each end head. In the operation by the brush gin the brush is set up to the saw cylinder so that the tips of the bristles overlap the saw teeth just $\frac{1}{32}$ in. and are then caused to rotate in the reverse direction to that of the saws, and at a peripheral speed of 6,300 ft. to 6,900 ft. per minute or approximately six times as fast as the saw teeth travel. When the bristles are new they have a wiping effect on the saw teeth, but after considerable use the tips wear off to such extent that they do not touch the saw teeth, and it is only the air blast generated by the brush that removes the lint. At the rear of the brush there is a board or sheet-metal cut-off, similar to that of a fan, and just above and between the saw cylinder and the brush there is a parting board that directs the air current on to the saw teeth, removing the lint and at the same time deflecting the motes out of the general current by centrifugal force with the assistance of the mote board, while the lint is blown into the lint flue below. The mote board is just below and between the saw cylinder and the brush, and is adjusted so that in the regulation thereof the motes just pass out while all of the lint cotton is caught in the lint flue. The usual air current or pressure produced on the saw teeth by the brush varies from 5 in. to 6·5 in. of water, and in its travel to the lint flue main body it expands until the pressure in the flue is $\frac{3}{4}$ in. to $\frac{1}{2}$ in. of water.

The discovery that the air blast generated by the brushes had such an important part in removing the lint from the saw teeth led to the discovery of the pneumatic gin. Figs. 11 and 12 show two different types of this gin. One (Fig. 11) discharges the motes below, while the other (Fig. 12) discharges them over the top of the air lip. In the early air attachments the discharge-nozzle opening was $\frac{7}{16}$ in. to $\frac{1}{2}$ in. wide and extended 1 in. beyond each end saw; after continued development, however, these openings were reduced to $\frac{1}{4}$ in. to $\frac{5}{16}$ in. The air blown from the lip opening continues to hug the sheet that leads to the lint-flue opening, and this sheet is brought up to within $\frac{1}{32}$ in. to $\frac{5}{32}$ in. of touching the saw teeth. The lint opening is just wide enough to receive all the air discharged from the air nozzle, and in addition thereto a small amount of the outside air is injected by the dynamic action of the air current. There is thus a slight current from the outside leading into the lint flue, to insure that there will not be a loss of lint fibres on the outside, which would be the case if the reverse action took place. The air pressure at the nozzle outlet is usually from 8 in. to 12 in. of water. The various pressures for other points in and around the air nozzle for the two types of gins considered are as shown in Figs. 13 and 14. The pressure in the lint flue at the rear of the gins varies from 0·7 in. to 1 in. in the rear of the gins to 0·5 in. to 0·65 in. in the lint-flue uptake to the condenser.

The Huller Gin.—The operation of the huller gin is very similar to that of the plain gin, in that the saw cylinders and the methods of removing the lint therefrom are the same. The roll-box construction is also the same except that there is an additional huller roll box in front of the ginning roll box, Figs. 5 and 9, for separating the seed cotton from the burrs, sticks, trash, &c., and the cotton is delivered into the huller roll box first, Fig. 5, and from there is carried up into the ginning roll box by the saws; hence the feed to the ginning roll box is from below instead of from the top, as is the case with the plain gin. The huller roll box, Fig. 5, consists of a chamber in which the cotton is fed, and this chamber has a hinged removable front cover *a*, with an inclined sheet or board for regulating the refuse discharge, and a huller picker roller *b*, $2\frac{1}{2}$ in. to $4\frac{1}{2}$ in. in diameter, with 10 to 16 longitudinal rows of No. 8 spikes set at an angle of 30 deg. to radius of point where they enter roller. These spikes are alternated and in circular rows of 5 to 8 spikes between each pair of saws, and project out $\frac{1}{2}$ in. to 1 in. from the roller, which rotates at from 300 r.p.m. to 700 r.p.m. There is also a set of huller ribs, Fig. 7, to prevent the hulls and trash from being carried into the upper or ginning roll box, thus performing a double ginning process. The huller ribs partly surround the huller picker roller, Fig. 9, and the outer or working surface of the rib is $\frac{1}{4}$ in. to $\frac{3}{8}$ in from the tips of the saw teeth; just below the seed grate the rib curves out and is fixed to a rib rail or bar.

In the operation of the huller gin the cotton, Fig. 5, is fed into the huller roll box, the spiked picker roller rotating in the reverse direction to that of the saws, spikes inclining backward. The cotton is thus thrown on to the saw teeth and carried up into the ginning roll, leaving the trash, a part of which is shed out; but as the quantity increases, the box front is swung out by hand, discharging the foreign substances. When there is a large amount of trash the picker roller is pulled out from the ribs and the inclined board moved back, thus permitting the trash to shed out in front of and behind the roller; but if there is only a small quantity, the huller roller should be set up close to it, to prevent the dropping of locks of cotton. The huller ribs are spaced sufficiently apart at the point where the teeth pass between to permit the seed cotton to pass through into the ginning roll box. The lint is removed from the saw teeth by means of a brush or current of air as has been described for plain gins, and the operation of the ginning roll box in shedding the seed is the same. The lint cotton is removed from the saw teeth and passes into the lint flue which has inlets from the various gins set in battery. The size of the lint flue varies according to the number and size of gins, the general practice being to have about 3 sq. in. per saw.

The Condenser.—The lint flue delivers the cotton into the condenser which consists of a large horizontal drum covered with 8-mesh No. 21 wire screen. The drum is usually 54 in. long, the same as the cotton bale, and its diameter is usually 30 in., 40 in., 50 in., 60 in., or 72 in. respectively, for 100, 175, 250, 325 or 400 saws. The screen drum, Fig. 15, is mounted in a housing that

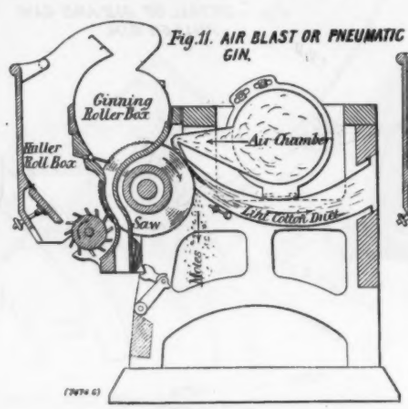


Fig. 11. AIR BLAST OR PNEUMATIC GIN.

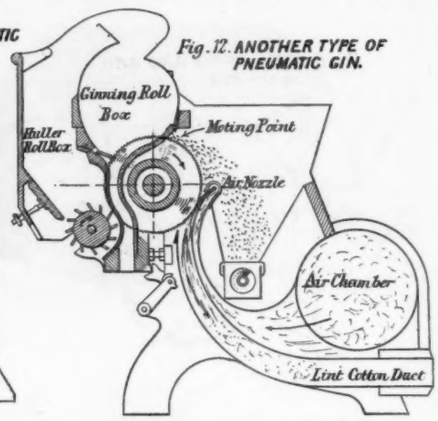


Fig. 12. ANOTHER TYPE OF PNEUMATIC GIN.

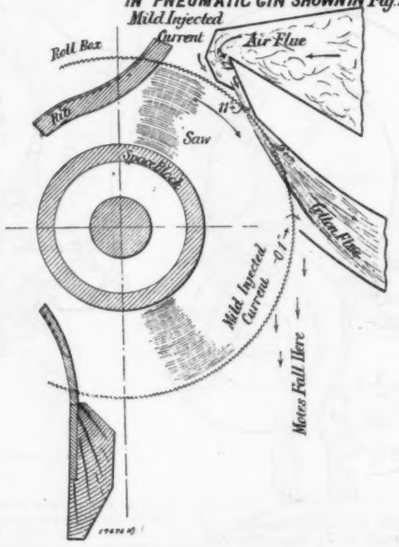


Fig. 13. AIR PRESSURE AT VARIOUS POINTS IN PNEUMATIC GIN SHOWN IN Fig. 11.

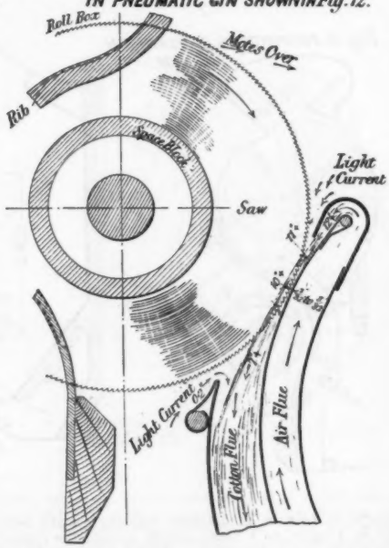


Fig. 14. AIR PRESSURE AT VARIOUS POINTS IN PNEUMATIC GIN SHOWN IN Fig. 12.

spirally circumscribes it with air outlets at the ends and two doffing rollers at the discharge side, the lower one having flaps of thin $\frac{5}{64}$-in. light cloth-backed rubber. The rollers receive the lint cotton from the drum and deliver it on the lint slide and then into the receiving chamber of the press box. The portion of the screen drum exposed to the cotton air current is about 75 per cent., and there is 1 sq. ft. of screen provided for every 5 to 6 saws; but when the drum rotates it travels at a rate of speed of 50 ft. to 80 ft. per minute for the smallest up to the largest-size condenser. This is equivalent to a screen exposure, when running, of from 2 sq. ft. down to 1 sq. ft. per saw per minute. The peripheral speed of the doffing rollers should be the same as that of the screen drum. From the condenser the lint cotton is delivered by the doffing rollers to the lint slide, thence into the press box.

The Cotton-Ginning Process.—The seed cotton is brought to the cotton-gin plant in quantities of 1,600 lb. when clean-picked cotton and of 2,000 lb. to 2,200 lb. when gathered or grabbed cotton. When ginned there will be a finished bale weighing about 500 lb. and 1,050 lb. of cotton seed; the remainder is refuse, as trash, hulls, dirt and other foreign substances. The seed cotton is usually hauled in wagons from which it is sucked off through a telescope by means of air-suction steel-plate centrifugal fans, operating at a blast-wheel peripheral speed of 11,000 ft. to 13,000 ft. per minute, and producing a vacuum of 14 in. to 16 in. of water. In the course of its travel the cotton is carried through a cleaner where it is agitated on a screen to remove the foreign substances; thence it passes to the elevating system where the air is separated from it, and is dropped into the gin feeders, where further cleaning is performed. The cotton is next delivered to the gin in such quantity as will not gorge the roll box, but will be sufficient to insure a nice, moderately soft, pliable ginning roll. If the cotton is clean picked it can be delivered direct to the ginning roll in a plain gin; but if gathered or grabbed, it will contain hulls, &c., and should be delivered to a huller roll box.

The seeds fall from the roll box down into a seed conveyor from which they are delivered to the customer's seed box or into a seed storage house. The hulls, trash and foreign substances are conveyed outside of the gin house to the boiler room for fuel—that is, that part that is combustible—or hauled off to be used later as fertiliser. The motes are also conveyed out and in some instances used for low-grade fibre stock. The lint cotton passes from the gin to the lint flue and then to the condenser, where it is separated from the air and formed into a bat. It is then delivered into the press box for packing, wrapping and pressing, ready for the market, and after marketing is compressed and re-wrapped before export.

LIGHT WAR OFFICE LORRY SPECIFICATION.—There has just been issued from the War Office a specification of a 30-cwt. light petrol lorry, which has been drawn up by the Transport Advisory Department. The vehicle is of a comparatively new type, comprehensive in its features and adaptable for service under varying conditions of climate and roads. The specification is a lengthy document, and appears to formulate a vehicle which should not only fulfil the arduous conditions of war service, but should also prove useful and economical for the transport of goods or passengers under ordinary commercial conditions. Details such as ball and roller bearings, magneto couplings, screw threads, &c., which have been standardised by the British Engineering Standards Association, are to conform to the requirements of this association. By building to this specification, manufacturers would be taking advantage of the unrivalled experience of the Motor Transport Services in the working of all kinds of vehicles in the recent war.